MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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E. B. KNOBEL, Esq., President, in the Chair.

The Rev. W. H. Addison, 8 West Chapel Street, Mayfair, W.;
Henry Baynham, Lieutenant R.N.R., Captain of H.M.S. "Wellesley," Training Ship, North Shields;
Humphrey Barker Chamberlin, 1033 Sixteenth Street, Denver, Colorado, U.S.A.;
Otto Jaffe, Kin Edar, Strandtown, Belfast, Ireland;
Charles Henry Johns, M.A., Althorpe House, Waverley Grove, Hendon, N.W.;
William Grant MacGregor, F.R.G.S., 18 Coleman Street, E.C.;
Captain R. Reynolds, Lieutenant R.N.R., Union Steamship "Pretoria," Southampton;
Albert Edward Watson, B.A., F.R.Met.Soc., Whitgift Grammar School, and 8 St. John's Grove, Croydon,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

The Rev. James Barnes Brearley, M.A., F.R.G.S., St. James's Church, Oldham, Lancashire (proposed by A. de Boë);
Herbert Hancock, M.A., F.R.Met.Soc., Lecturer on Geometry to the Architectural Association, and Mathematical Master in Bancroft's School, Woodford, Essex (proposed by W. H. Besant);
Thomas Torrens Knowles, M.A., Cambridge Extension Lecturer in Chemistry, Lancashire County Council Lecturer in Physics, Mathematical and Science Master,

Royal Grammar School, Lancaster (proposed by John Bone);

Alfred Thomas Odell-Lorrell, Science Lecturer and Examiner, 1 St. Mary's Grove, Chiswick, W. (proposed by D. Milligan);

Edward Stroud, Prisca Coborn Foundation School, Tredegar Square, E. (proposed by J. McCarthy);

John Tatlock, Jun., M.A., New York City, U.S.A. (proposed by S. W. Burnham).

The following were proposed by the Council as Associates of the Society:—

W. L. Elkin, Yale College Observatory, New Haven, Connecticut, U.S.A.;

J. C. Kapteyn, Observatory, Gröningen, Holland;

Hugo Seeliger, Royal Observatory, Munich, Bavaria;

Hermann Struve, Observatory, Pulkowa, Russia.

Seventy-seven presents were announced as having been received since the last meeting, including, amongst others:—

Original negatives of *Jupiter* (12 plates), taken with the great telescope of the Lick Observatory, presented by the Observatory; Original negative of Swift's Comet, taken at the Sydney Observatory, presented by H. C. Russell; Photograph of the region surrounding *η Argûs*, enlargement from a negative taken by Dr. Gill at the Royal Observatory, Cape of Good Hope, presented by the President; Photographs of the "Crab" Nebula (1 M *Tauri*), presented by Isaac Roberts; R. Wolf, *Geschichte der Astronomie*, third half-volume, presented by the author; Photograph of the Total Solar Eclipse of 1871 (positive copy on glass), taken in Java, presented by Professor Oudemans; Oxygen bottle for use with the lantern at evening meetings, presented by E. Ristori.

Observations of the Moon made at the Radcliffe Observatory, Oxford, during the year 1891; *and a Comparison of the Results with the Tabular Places from Hansen's Lunar Tables.* By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

The present paper contains the observations of the Right Ascensions and North Polar Distances of the Moon, made at the Radcliffe Observatory during the year 1891. These results are here compared with those deduced from Hansen's Lunar Tables on two suppositions:—

(1) That the mean times found in the usual way, from the sidereal times at mean noon given in the *Nautical Almanac*, were not altered in scale, or affected with any different systematic errors of determination, by

the adoption in 1864 of a different ratio of the Julian year of $365\frac{1}{4}$ "mean solar days" to the mean tropical year.

(2) That the "mean times," which accurately correspond to a given "sidereal time of a meridian," were necessarily changed in 1864 by the use of a different ratio of the "Julian year" and therefore of the "mean solar day," to the mean tropical year, to fix the tabular Right Ascensions of the clock stars at the meridian transits. It is from these tabular Right Ascensions of the clock stars that the observed Right Ascensions are deduced by the aid of clocks; and the Right Ascensions thus found are finally rendered definite by a direct reference to the positions of the Sun deduced from the North Polar Distances and Obliquities of the Ecliptic.

In the Appendix to the *Monthly Notices*, vol. l., will be found the results of a comparison between the Greenwich Lunar Observations, 1847–1861, and Hansen's Tables, of greater accuracy than had before been available for use; and these results have been utilised to form the mean results given in Table III.

An examination of the residual errors shows that the motion of the Moon was closely represented by Hansen's Tables during the period 1847–1863, although periodical errors of no inconsiderable amount, due either to defects of theory or to imperfections in the practical methods of comparing the theoretical and observational results, are shown to exist.

The mean annual error in longitude of Hansen's Tables from 1847 to 1863 is, however, only $-1''\cdot85$, and no law of regular increase is apparent; but Table III. shows that when the time, t, is found as at present, the mean annual error has increased since 1863 at an average rate of $0''\cdot75$ per annum, and that the error now amounts to $+19''$. The mean annual error of Hansen's Tables from 1864 to 1891 taken out with the *corrected* argument is $-1''\cdot49$, which differs but very slightly from the mean error between 1847 and 1863.

For facilities for an accurate comparison between Hansen's Lunar Tables and Observations I am again indebted to the places published in the *Connaissance des Temps*.

TABLE I.

Radcliffe Observations of the Moon, 1891.

R.A.'s and N.P.D.'s of the Centre of the Moon, 1891; *compared with Hansen's Tabular Places*, **Uncorrected** *and* **Corrected** *for the change in the Unit of Mean Time introduced in the year* 1864.

Day, 1891.	Correction to be subtracted from M.T. for change of Sidereal Time at Mean Noon since 1864.	Observer.	Limb observed in R.A.	Observed R.A.	R.A. from Hansen's Tables for Uncorrected Mean Times.	Hansen *minus* Observed. **Uncorrected.**	Correction due to the Change in the Unit of Mean Time.	Hansen *minus* Observed. **Corrected.**	Limb observed in N.P.D.	Observed N.P.D.	N.P.D. from Hansen's Tables for Uncorrected Mean Times.	Hansen *minus* Observed. **Uncorrected.**	Correction due to the Change in the Unit of Mean Time.	Hansen *minus* Observed. **Corrected.**
	s			h m s	s	s	s	s		° ′ ″	″	″	″	″
Jan. 4	40·04	R.	II.	14 20 3·13	4·12	+0·99	−1·33	−0·34	S.	100 33 55·53	63·31	+ 7·78	− 8·37	−0·59
5	40·05	R.	II.	15 11 8·18	9·27	+1·09	−1·43	−0·34	S.	105 32 30·41	37·73	+ 7·32	− 7·62	−0·30
16	40·09	R.	I.	1 19 1·12	2·19	+1·07	−1·40	−0·33	S.	86 10 50·53	42·12	− 8·41	+ 9·79	+1·38
17	40·09	R.	I.	2 10 42·46	43·65	+1·19	−1·39	−0·20	S.	80 21 10·66	2·68	− 7·98	+ 8·98	+1·00
21	40·11	R.	I.	5 46 33·76	35·14	+1·38	−1·51	−0·13	N.&S.	65 25 6·06	3·46	− 2·60	+ 2·29	−0·31
22	40·11	W.	I.	6 42 53·89	55·26	+1·37	−1·51	−0·14	N.	64 40 1·95	2·50	+ 0·55	+ 0·13	+0·68
24	40·12	R.	I. & II.	8 32 33·85	35·06	+1·21	−1·43	−0·22	N.	67 3 34·65	38·20	+ 3·55	− 3·85	−0·30
29	40·14	F. B.	II.	12 29 40·60	41·82	+1·22	−1·20	+0·02	S.	88 7 33·44	39·11	+ 5·67	− 8·54	−2·87
Feb. 1	40·15	R.	II.	14 48 27·24	28·24	+1·00	−1·35	−0·35	S.	103 39 8·07	16·07	+ 8·00	− 7·80	+0·20
16	40·21	F. B.	I.	4 33 18·45	19·71	+1·26	−1·50	−0·24	S.	68 10 47·93	44·30	− 3·63	+ 5·00	+1·37
17	40·22	R.	I.	5 29 9·92	11·03	+1·11	−1·51	−0·40	S.	65 43 39·01	37·41	− 1·60	+ 2·91	+1·31
23	40·24	F. B.	II.	10 44 31·97	33·18	+1·21	−1·26	−0·05	N.	76 38 20·36	27·75	+ 7·39	− 7·42	−0·03
25	40·25	R.	II.	12 14 49·18	50·13	+0·95	−1·21	−0·26	S.	86 33 31·22	38·62	+ 7·40	− 8·56	−1·16
26	40·25	F. B.	II.	12 59 12·62	13·73	+1·11	−1·21	−0·10	S.	91 51 16·31	25·12	+ 8·81	− 8·68	+0·13

Day, 1891.	Correction to be subtracted from M.T. for change of Sidereal Time at Mean Noon since 1864.	Observer.	Limb observed in R.A.	Observed R.A.	R.A. from Hansen's Tables for Uncorrected Mean Times.	Hansen *minus* Observed. **Uncorrected.**	Correction due to the Change in the Unit of Mean Time.	Hansen *minus* Observed. **Corrected.**	Limb observed in N.P.D.	Observed N.P.D.	N.P.D. from Hansen's Tables for Uncorrected Mean Times.	Hansen *minus* Observed. **Uncorrected.**	Correction due to the Change in the Unit of Mean Time.	Hansen *minus* Observed. **Corrected.**
	s			h m s	s	s	s	s		° ′ ″	″	″	″	″
Feb. 27	40·26	W.	II.	13 44 19·54	20·76	+1·22	−1·24	−0·02	S.	97 8 12·04	23·81	+11·77	−8·50	+3·27
Mar. 20	40·34	R.	I.	8 50 47·95	49·06	+1·11	−1·40	−0·29	N.	67 44 28·49	31·84	+3·35	−4·58	−1·23
21	40·35	F. B.	I.	9 41 8·21	9·32	+1·11	−1·33	−0·22	N.	71 1 3·60	7·45	+3·85	−6·04	−2·19
26	40·37	F. B.	II.	13 29 40·56	41·63	+1·07	−1·24	−0·17	S.	95 35 35·53	44·86	+9·33	−8·74	+0·59
30	40·38	F. B.	II.	16 52 23·07	24·40	+1·33	−1·56	−0·23	S.	113 13 49·45	56·63	+7·18	−4·44	+2·74
Apr. 17	40·45	R.	I.	9 23 36·90	37·86	+0·96	−1·37	−0·41	N.	69 33 51·90	55·98	+4·08	−5·63	−1·55
20	40·47	W.	I.	11 44 19·43	20·31	+0·88	−1·22	−0·34	N.	82 55 53·93	59·07	+5·14	−8·50	−3·36
22	40·47	R.	I.	13 13 46·35	47·20	+0·85	−1·24	−0·39	N.	93 41 56·94	64·64	+7·70	−8·95	−1·25
23	40·48	F. B.	I. & II.	13 59 55·42	56·54	+1·12	−1·29	−0·17	N. & S.	99 5 36·23	43·13	+6·90	−8·67	−1·77
25	40·49	R.	II.	15 39 43·47	44·56	+1·09	−1·45	−0·36	S.	108 45 32·61	37·83	+5·22	−6·82	−1·60
May 15	40·57	R.	I.	9 53 41·54	42·45	+0·91	−1·34	−0·43	N.	71 42 5·56	10·40	+4·84	−6·51	−1·67
16	40·57	F. B.	I.	10 41 19·62	20·70	+1·08	−1·27	−0·19	N.	76 0 25·63	30·46	+4·83	−7·57	−2·74
19	40·58	R.	I.	12 56 2·49	3·37	+0·88	−1·23	−0·35	N.	91 29 28·23	34·97	+6·74	−8·99	−2·25
31	40·63	R.	II.	0 10 39·28	40·63	+1·35	−1·45	−0·10	N.	94 2 37·28	26·16	−11·12	+10·46	−0·66
June 12	40·68	R.	I.	10 22 2·39	3·35	+0·96	−1·31	−0·35	N.	74 10 34·48	39·92	+5·44	−7·23	−1·79
16	40·69	R.	I.	13 22 4·81	5·61	+0·80	−1·24	−0·44	N.	94 40 8·05	15·73	+7·68	−8·93	−1·25
19	40·71	R.	I.	15 49 59·28	60·62	+1·34	−1·50	−0·16	N.	109 33 32·90	39·38	+6·48	−6·70	−0·22
20	40·71	F. B.	I.	16 47 8·19	9·76	+1·57	−1·62	−0·05	N. & S.	113 7 50·76	55·49	+4·73	−4·87	−0·14

Day, 1891.	Correction to be subtracted from M.T. for change of Sidereal Time at Mean Noon since 1864.	Observer.	Limb observed in R.A.	Observed R.A.	R.A. from Hansen's Tables for Uncorrected Mean Times.	Hansen *minus* Observed. **Uncorrected.**	Correction due to the Change in the Unit of Mean Time.	Hansen *minus* Observed. **Corrected.**	Limb observed in N.P.D.	Observed N.P.D.	N.P.D. from Hansen's Tables for Uncorrected Mean Times.	Hansen *minus* Observed. **Uncorrected.**	Correction due to the Change in the Unit of Mean Time.	Hansen *minus* Observed. **Corrected.**
	s			h m s	s	s	s	s		° ′ ″	″	″	″	″
June 25	40·73	F. B.	II.	22 2 49·13	50·94	+1·81	−1·61	+0·20	N.	107 28 46·57	37·99	−8·58	+8·21	−0·37
July 16	40·81	R.	I.	15 25 21·99	23·01	+1·02	−1·43	−0·41	N.	107 43 13·74	17·78	+4·04	−7·22	−3·18
17	40·82	F. B.	I.	16 19 49·15	50·53	+1·38	−1·55	−0·17	N.	111 41 25·32	30·96	+5·64	−5·73	−0·09
24	40·85	R.	II.	23 35 29·25	30·83	+1·58	−1·52	+0·06	N.	97 55 36·25	25·52	−10·73	+10·53	−0·20
27	40·86	F. B.	II.	2 16 26·27	27·82	+1·55	−1·47	+0·08	N.	78 50 50·82	41·81	−9·01	+9·51	+0·50
Aug. 13	40·93	W.	I.	15 55 10·52	11·79	+1·27	−1·47	−0·20	N.	110 16 23·34	27·21	+3·87	−6·30	−2·43
27	40·98	W.	II.	5 44 36·03	37·76	+1·73	−1·61	+0·12	N.	64 23 41·36	39·52	−1·84	+2·32	+0·48
Sept. 10	41·04	W.	I.	16 28 23·14	24·42	+1·28	−1·51	−0·23	N.	112 40 46·60	49·83	+3·23	−5·18	−1·95
11	41·04	R.	I.	17 25 23·73	24·78	+1·05	−1·62	−0·57	N.	115 13 23·27	27·23	+3·96	−3·12	+0·84
12	41·05	F. B.	I.	18 26 10·94	12·38	+1·44	−1·71	−0·27	S.	116 22 19·82	17·49	−2·33	−0·57	−2·90
14	41·05	W.	I.	20 33 46·97	48·47	+1·50	−1·75	−0·25	S.	113 32 28·82	25·04	−3·78	+5·27	+1·49
15	41·06	R.	I.	21 36 58·10	59·55	+1·45	−1·71	−0·26	S.	109 30 30·67	22·47	−8·20	+7·92	−0·28
16	41·06	F. B.	I.	22 38 2·82	4·40	+1·58	−1·64	−0·06	S.	104 2 12·08	1·85	−10·23	+9·97	−0·26
23	41·09	R.	II.	5 24 9·20	10·86	+1·66	−1·65	+0·01	N.	64 43 19·68	16·35	−3·33	+3·23	−0·10
Oct. 12	41·17	F. B.	I.	21 8 33·90	35·35	+1·45	−1·67	−0·22	S.	111 42 38·62	34·72	−3·90	+6·61	+2·71
14	41·17	R.	I.	23 6 50·07	51·29	+1·22	−1·58	−0·36	S.	101 5 10·14	0·49	−9·65	+10·56	+0·91
15	41·18	W.	I.	0 3 40·45	41·85	+1·40	−1·56	−0·16	S.	94 22 43·26	33·60	−9·66	+11·50	+1·84
16	41·18	R.	I.	1 0 0·76	2·01	+1·25	−1·56	−0·31	S.	87 20 31·93	21·27	−10·66	+11·64	+0·98

Day, 1891.	Correction to be subtracted from M.T. for change of Sidereal Time at Mean Noon since 1864.	Observer.	Limb observed in R.A.	Observed R.A.	R.A. from Hansen's Tables for Uncorrected Mean Times.	Hansen *minus* Observed. **Uncorrected.**	Correction due to the Change in the Unit of Mean Time.	Hansen *minus* Observed. **Corrected.**	Limb observed in N.P.D.	Observed N.P.D.	N.P.D. from Hansen's Tables for Uncorrected Mean Times.	Hansen *minus* Observed. **Uncorrected.**	Correction due to the Change in the Unit of Mean Time.	Hansen *minus* Observed. **Corrected.**
	s			h m s	s	s	s	s		° ′ ″	″	″	″	″
Oct. 23	41·21	W.	II.	7 58 45·17	46·81	+1·64	−1·57	+0·07	S.	64 42 32·93	36·51	+ 3·58	− 3·29	+0·29
Nov. 9	41·28	W.	I.	21 46 15·85	17·25	+1·40	−1·60	−0·20	S.	109 1 66·77	59·26	− 7·51	+ 7·85	+0·34
11	41·29	F. B.	I.	23 38 13·76	15·09	+1·33	−1·51	−0·18	S.	97 32 34·31	25·02	− 9·29	+10·84	+1·55
13	41·29	R.	I.	1 27 40·28	41·42	+1·14	−1·54	−0·40	S.	83 57 46·35	35·88	−10·47	+11·23	+0·76
17	41·31	W.	II.	5 27 58·90	60·59	+1·69	−1·76	−0·07	N.	64 22 22·97	21·41	− 1·56	+ 3·30	+1·74
20	41·32	W.	II.	8 30 57·54	59·13	+1·59	−1·55	+0·04	S.	66 0 19·85	25·50	+ 5·65	− 4·59	+1·06
22	41·33	R.	II.	10 14 48·25	49·40	+1·15	−1·34	−0·19	S.	73 28 0·06	5·41	+ 5·35	− 7·54	−2·19
Dec. 8	41·39	R.	I.	23 19 52·59	53·85	+1·26	−1·49	−0·23	S.	99 39 39·82	29·88	− 9·94	+10·27	+0·33
11	41·41	R.	I.	1 59 28·79	29·99	+1·20	−1·52	−0·32	S.	80 9 57·21	46·41	−10·80	+10·47	−0·33
15	41·42	W.	II.	5 59 49·26	50·87	+1·61	−1·76	−0·15	N.	63 37 45·70	43·59	− 2·11	− 1·80	−0·31
16	41·43	R.	II.	7 3 0·30	1·83	+1·53	−1·72	−0·19	N.	63 25 44·88	46·58	+ 1·70	− 1·10	+0·60
17	41·43	F. B.	II.	8 3 43·44	44·95	+1·51	−1·63	−0·12	S.	64 53 22·58	27·90	+ 5·32	− 3·66	+1·66
18	41·43	W.	II.	9 0 33·91	35·44	+1·53	−1·52	+0·01	S.	67 44 3·89	11·39	+ 7·50	− 5·71	+1·79
20	41·44	R.	II.	10 41 56·02	57·23	+1·21	−1·32	−0·11	S.	76 14 39·28	46·42	+ 7·14	− 8·21	−1·07
22	41·45	W.	II.	12 11 54·33	55·55	+1·22	−1·22	0·00	S.	86 41 6·74	16·72	+ 9·98	− 9·13	+0·85
Mean of Errors, without regard to sign ...					...	s 1·268	...	s 0·216		...	...	″ 6·271	...	″ 1·204
Mean Errors for year					...	+1·268	...	−0·197						

TABLE II.

Radcliffe Observations of the Moon, 1891.

Errors of the Moon's Tabular Place in Longitude and Ecliptic Polar Distance, **Uncorrected** *and* **Corrected** *for the Change in the Unit of Mean Time introduced in the year* 1864.

Day, 1891.	Observer.	Limb observed in R.A.	Limb observed in N.P.D.	Errors of Longitude (Hansen *minus* Observed). Uncorrected.	Corrected.	Errors of E.N.P.D. (Hansen *minus* Observed). Uncorrected.	Corrected.
Jan. 4	R.	II.	S.	+16″·37	−4″·94	+2″·60	+1″·08
5	R.	II.	S.	+17·16	−4·82	+2·85	+1·02
Jan. 16	R.	I.	S.	+18·07	−5·11	−1·77	−0·58
17	R.	I.	S.	+19·31	−3·13	−1·59	−0·05
21	R.	I.	N. & S.	+18·87	−1·76	−2·13	−0·35
22	W.	I.	N.	+18·55	−1·84	−0·79	+0·82
24	R.	I. & II.	N.	+17·10	−3·02	−0·66	+0·45
29	F.B.	II.	S.	+19·18	−0·87	−2·02	−2·76
Feb. 1	R.	II.	S.	+16·33	−4·82	+3·32	+1·70
Feb. 16	F.B.	I.	S.	+17·92	−3·51	−1·02	+0·86
17	R.	I.	S.	+15·23	−5·53	−0·83	+1·03
23	F.B.	II.	N.	+19·20	−0·69	+0·17	+0·25
25	R.	II.	S.	+16·10	−4·06	+1·13	+0·49
26	F.B.	II.	S.	+18·78	−1·33	+1·71	+0·70
27	W.	II.	S.	+21·23	+0·90	+4·46	+3·16
Mar. 20	R.	I.	N.	+15·79	−4·22	−0·93	−0·10
21	F.B.	I.	N.	+16·19	−3·68	−1·52	−1·05
26	F.B.	II.	S.	+18·34	−2·15	+2·77	+1·48
30	F.B.	II.	S.	+19·04	−2·83	+5·01	+3·09
Apr. 17	R.	I.	N.	+14·15	−5·98	−0·32	+0·32
20	W.	I.	N.	+14·14	−6·01	−0·50	−1·07
22	R.	I.	N.	+14·73	−5·89	+2·31	+1·05
23	F.B.	I. & II.	N. & S.	+17·98	−2·98	+0·73	−0·79
25	R.	II.	S.	+16·27	−5·34	+1·55	−0·39
May 15	R.	I.	N.	+13·89	−6·35	+0·13	+0·52
16	F.B.	I.	N.	+16·45	−3·61	−1·45	−1·50
19	R.	I.	N.	+14·82	−5·73	+1·10	−0·04
31	R.	II.	N.	+23·12	−1·12	−2·17	−1·21
June 12	R.	I.	N.	+14·94	−5·38	+0·03	+0·17
16	R.	I.	N.	+14·01	−6·59	+2·63	+1·31
19	R.	I.	N.	+19·89	−2·26	+2·28	+0·27
20	F.B.	I.	N. & S.	+22·08	−0·70	+2·00	−0·05
25	F.B.	II.	N.	+27·37	+2·82	+0·97	+0·65

Day, 1891.	Observer.	Limb observed in R.A.	Limb observed in N.P.D.	Errors of Longitude (Hansen *minus* Observed). Uncorrected.	Errors of Longitude (Hansen *minus* Observed). Corrected.	Errors of E.N.P.D. (Hansen *minus* Observed). Uncorrected.	Errors of E.N.P.D. (Hansen *minus* Observed). Corrected.
July 16	R.	I.	N.	+15″·14	−6″·48	+0″·30	−1″·63
17	F.B.	I.	N.	+19·91	−2·35	+2·33	+0·31
24	R.	II.	N.	+25·91	+0·90	−0·51	+0·17
27	F.B.	II.	N.	+24·54	+0·95	−0·97	+0·86
Aug. 13	W.	I.	N.	+18·29	−3·25	+0·12	−1·80
27	W.	II.	N.	+23·48	+1·61	−1·18	+0·53
Sept. 10	W.	I.	N.	+18·01	−3·45	+0·44	−1·43
11	R.	I.	N.	+14·47	−7·67	+3·10	+1·30
12	F.B.	I.	S.	+19·43	−3·49	−1·45	−3·06
14	W.	I.	S.	+21·00	−3·72	+1·47	+0·59
15	R.	I.	S.	+22·15	−3·40	−1·14	−1·45
16	F.B.	I.	S.	+25·26	−0·71	−0·87	−0·57
23	R.	II.	N.	+22·70	+0·14	−1·91	−0·09
Oct. 12	F.B.	I.	S.	+20·53	−3·74	+2·17	+1·70
14	R.	I.	S.	+20·39	−5·26	−1·92	−1·22
15	W.	I.	S.	+23·16	−2·94	−0·51	+0·73
16	R.	I.	S.	+21·43	−4·67	−2·63	−0·88
23	W.	II.	S.	+22·59	+0·99	−0·87	+0·10
Nov. 9	W.	I.	S.	+21·32	−2·80	−0·46	−0·62
11	F.B.	I.	S.	+21·92	−3·08	−0·67	+0·36
13	R.	I.	S.	+19·71	−5·83	−3·42	−1·50
17	W.	II.	N.	+22·90	−1·04	−0·29	+1·68
20	W.	II.	S.	+22·58	+0·79	+0·18	+0·89
22	R.	II.	S.	+17·44	−3·35	−0·91	−1·07
Dec. 8	R.	I.	S.	+21·11	−3·27	−1·81	−1·03
11	R.	I.	S.	+20·39	−4·33	−4·01	−1·94
15	W.	II.	N.	+21·64	−2·02	−2·11	−0·31
16	R.	II.	N.	+20·65	−2·47	−0·56	+0·87
17	F.B.	II.	S.	+21·23	−1·26	+0·98	+1·96
18	W.	II.	S.	+22·57	+0·64	+1·18	+1·68
20	R.	II.	S.	+19·10	−1·90	−0·03	−0·39
22	W.	II.	S.	+20·85	+0·34	+1·90	+0·78
Mean of Errors, without regard to sign		...	...	... **19″·298**	**3″·212**	**1″·505**	**0″·982**
Mean Errors for Year		...	...	... **+19″·298**	**−2″·902**	...	...

Observers: W., Mr. W. Wickham; R., Mr. W. H. Robinson; F.B., Mr. F. A. Bellamy.

TABLE III.

Mean Excess over Observation of the Moon's Tabular Place in Longitude for the years 1847 *to* 1891, *as computed from Hansen's Tables.*

Uncorrected *and* **Corrected** *for the change in the Unit of Mean Time introduced in the year* 1864.

Year.	Errors of Longitude (Hansen *minus* Observed). Uncorrected.	Corrected.
	″	″
1847	+ 0·51	+ 0·51
1848	− 0·53	− 0·53
1849	− 1·08	− 1·08
1850	− 0·97	− 0·97
1851	− 1·93	− 1·93
1852	− 1·57	− 1·57
1853	− 2·18	− 2·18
1854	− 2·34	− 2·34
1855	− 1·40	− 1·40
1856	− 1·51	− 1·51
1857	− 2·41	− 2·41
1858	− 2·61	− 2·61
1859	− 2·49	− 2·49
1860	− 3·62	− 3·62
1861	− 2·95	− 2·95
1862	− 2·83	− 2·83
1863	− 1·61	− 1·61
1864	+ 0·12	− 0·81
1865	+ 1·27	− 0·22
1866	+ 2·14	− 0·22
1867	+ 3·48	+ 0·36
1868	+ 4·12	+ 0·28
1869	+ 4·28	− 0·35
1870	+ 4·83	− 0·66
1871	+ 6·96	+ 0·44
1872	+ 7·31	+ 0·10
1873	+ 8·24	+ 0·20
1874	+ 9·29	+ 0·56
1875	+ 9·87	+ 0·36
1876	+ 9·80	− 0·50
1877	+ 9·23	− 1·90
1878	+ 8·22	− 3·60
1879	+ 9·63	− 3·12
1880	+ 10·89	− 2·77
1881	+ 10·51	− 4·06
1882	+ 12·68	− 2·51
1883	+ 14·71	− 1·50
1884	+ 14·65	− 1·91
1885	+ 15·20	− 1·82
1886	+ 15·34	− 2·53
1887	+ 15·70	− 3·25
1888	+ 17·68	− 2·46
1889	+ 17 37	− 3·51
1890	+ 18 02	− 3·55
1891	+ 19 30	− 2·90

1847 to 1879: Greenwich observations. 1880 to 1882: Mean of Greenwich and Radcliffe. 1883 to 1891: Radcliffe observations.

Radcliffe Observatory, Oxford:
1892 *May* 13.

Note on the Secular Perturbations of the Earth by Mars.

By R. T. A. Innes.

In my computation, printed in this volume on pages 80 to 87, I do not find for $\left[\frac{dp}{dt}\right]_{00}$ and $\left[\frac{dq}{dt}\right]_{00}$ the values given by Le Verrier in *Mémoires de l'Observatoire de Paris*, tome ii. Mr. Asaph Hall, Jun., has also performed the calculation by Gauss's method,* and finds for these functions practically the same values as computed by Professor Hill by algebraical expansion.† I therefore revised my figures, and not finding any material difference I examined the formulæ given in vol. i. of the *Astronomical Papers of the American Ephemeris*, with the result that I found a misprint in the value of J_3 on pages 338 and 359. For sin Π read sin Π′. My figures, altered accordingly, make J_3 so nearly the value found by Mr. Hall that it is needless to finish the calculation.

It will be interesting to compare the values of the secular perturbations of the Earth caused by *Mars* found by Le Verrier and Professor Hill by expansion with those found by Gauss's method by Mr. Hall and myself. Reducing all to the mass of *Mars* used by Mr. Hall, viz. $\frac{1}{m'} = 3093500$, we have—

$\left[\frac{de}{dt}\right]_{00}$	$-0''.015723$ Hall.	$\left[\frac{d\pi}{dt}\right]_{00}$	$+0''.975139$ Hall.
	-0.015734 Le Verrier.		$+0.975430$ Le Verrier.
	-0.015722 Innes.		$+0.975224$ Innes.
$\left[\frac{dp}{dt}\right]_{00}$	$+0.006344$ Hall.	$\left[\frac{dq}{dt}\right]_{00}$	-0.007195 Hall.
	$+0.006336$ Hill.		-0.007211 Hill.
	$+0.006351$ Le Verrier.		-0.007209 Le Verrier.

$$\left[\frac{dL}{dt}\right]_{00} \quad \begin{matrix} 0''.23424 \text{ Hall.} \\ 0.23368 \text{ Le Verrier.} \\ 0.23469 \text{ Innes.} \end{matrix}$$

Erratum in my previous communication:—

$$\text{Page 81, read } \nu' = \frac{\sqrt{3}}{32\, m_{,}^{\,2}} \left\{ 1 + 2\frac{\lambda^4}{m_{,}^{\,2} m_{,,}^{\,2}} + 4\frac{\lambda^{12}}{m_{,}^{\,6} m_{,,}^{\,4} m_{,,,}^{\,2}} + \&c. \right\}$$

There are a few other misprints, but they are of no importance.

The second part of the expression for J_3 on page 81, and J_3 and $\frac{a}{r} W_0$ on page 85, are incorrect for the reason pointed out above.

* *Astronomical Journal*, vol. xi., No. 4, July 24, 1891.

† *Astronomical Papers of the American Ephemeris*, vol. iv., pp. 511–12.

Sydney: 1892 *March* 7.

On a New Form of Altazimuth. By W. H. M. Christie, M.A., F.R.S., Astronomer Royal.

The altazimuth proposed is a reversible transit-circle with iron stand, capable of being placed in different definite azimuths, say 0°, 20°, 40°, 60°, 75°, 90° E. or W. of the meridian, the instrument being used as a transit-circle in any one of these azimuths. This may be arranged by mounting the iron supports of the transit-circle on a circular base resting at three parts of its circumference on a circular casting carefully planed on its upper surface and bolted to the foundation pier. By the help of friction rollers, brought into action to take off part of the weight, the transit-circle could be rotated round a central pivot from one definite azimuth to another, suitable arrangements being made for locking it firmly in the required position, as in the case of a railway turntable. In fact, the transit-circle would be mounted on a turntable with provision for bringing it into definite azimuths and for securing its fixity when brought into position. The proposed altazimuth would thus be essentially a transit-circle capable of being used out of the meridian, in the prime vertical or in any other selected azimuthal plane. It would differ in principle from the well-known form of transit-instrument in the prime vertical, as the zenith-distance of the object would be observed (by means of the vertical circle) as well as the time of azimuthal transit, and a complete determination of the position of the object (R.A. as well as N.P.D.) would be made by a method of observation and reduction essentially different, and applicable in any azimuthal plane.

The principle of the method of observing would be that the observations of azimuth and zenith-distance should be referred to the same instant of time and that from these the R.A. and N.P.D. would be deduced subject to corrections for the instrumental errors of collimation, level and azimuth (difference from assumed azimuth).* The computations would thus be greatly simplified, and tables could be readily formed for the given azimuths of auxiliary quantities which would render the reductions very easy.

Transits should be taken over vertical wires (say two sets of five, omitting the central wire), and over horizontal wires (say two sets of five, omitting the central wire) arranged so that, generally, the horizontal and vertical transits would not interfere with each other, and that the mean of the time of transits over the vertical and horizontal wires respectively would differ only by a small quantity. This condition may be secured by having in addition to the systems of vertical and horizontal wires (each carried on a micrometer slide as usual in a transit-circle) a wire

* The observed Z.D. and time of transit might be corrected for the effect of errors of collimation and level before the computation of N.P.D. and R.A., but the corrections would, I believe, involve a little more labour.

carried by a position-circle micrometer, which would be set to the approximate inclination of the path of the object to be observed. The telescope having been set to the computed Z.D. and clamped, when the object enters the field it is to be bisected (approximately, with allowance for curvature of path if necessary) by the position-circle wire by means of its micrometer screw, or by the slow motion in Z.D., and the middle horizontal wire is to be made to bisect this wire at its intersection with the middle vertical wire by means of the Z.D. micrometer. The object should thus transit simultaneously over the middle horizontal and vertical wires and the means of the times of transit over the two sets of wires would not differ by more than a very small quantity, say δt.

[As an alternative method of observing the Z.D , the object might be bisected by the wire of the position micrometer (set to the approximate position angle of the diurnal path) at its transit over the middle and pairs of vertical wires, as in zenith-distance observations with a meridian transit-circle.]

Let t, $t+\delta t$ be means of times of transit over the vertical and horizontal wires respectively, z' the observed zenith distance (corrected for refraction and parallax), $z = z' - \delta z$ the Z.D. at time t.

A the assumed azimuth (not greater than 90°, and reckoned positive from South towards West), γ the co-latitude, h the hour angle (in arc), Δ the N.P.D., and S the parallactic angle.

Then we have,

$$\delta z = 15 \sin S \sin \Delta \delta t = 15 \sin \gamma \sin A \, \delta t = 15 m \, \delta t$$

where

$$m = \sin \gamma \sin A, \text{ a constant for a given azimuth,}$$

whence

$$z = z' - \delta z \text{ is known.}$$

Therefore, putting

$$\tan \theta = \tan \gamma \cos A,$$

and

$$n = \frac{\cos \gamma}{\cos \theta}$$

where θ and n are constants

$$\cos \Delta = \frac{\cos \gamma \cos (z+\theta)}{\cos \theta} = n \cos (z+\theta) \qquad (1)$$

$$\sin h = \frac{\sin A \, . \, \sin z}{\sin \Delta} \qquad (2)$$

which give the N.P.D. and hour angle, uncorrected for instrumental errors. Also the parallactic angle is given by

$$\sin S = \frac{\sin \gamma \sin A}{\sin \Delta} = m \operatorname{cosec} \Delta.$$

It has been assumed so far that the object was observed at the assumed azimuth A at time t, and corrections for errors of

collimation (c), level (l), and azimuth (a), must now be applied to Δ and h viz.:—

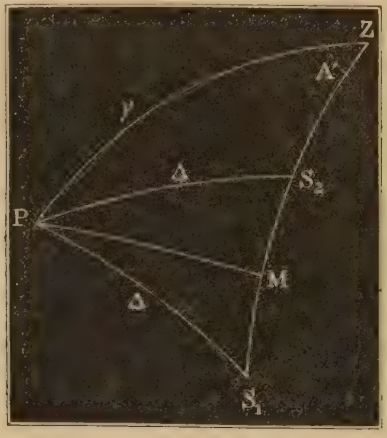
Collimation	$\delta\Delta = c \sin S$	$\delta h = c \cos S \operatorname{cosec} \Delta$
Level	$\delta'\Delta = l \cos z \sin S$	$\delta' h = l \cos z \cos S \operatorname{cosec} \Delta$
Azimuth	$\delta''\Delta = a \sin z \sin S$	$\delta'' h = a \sin z \cos S \operatorname{cosec} \Delta$

The factors $\sin S$, $\cos z \sin S$, $\sin z \sin S$, $\cos S \operatorname{cosec} \Delta$, $\cos z \cos S \operatorname{cosec} \Delta$, $\sin z \cos S \operatorname{cosec} \Delta$ may be tabulated to three places of decimals for the given azimuths, and at convenient intervals of Z.D. or N.P.D., but probably only two places of decimals would be required in most cases, so that the corrections would be very easily made.

Thus the N.P.D. and hour angle are determined, and from the latter in combination with the time of transit the R.A. of the object is at once obtained if the clock error is known. Reciprocally, the clock error would be found from observations of clock stars, the R.A. of which is known.

It remains to consider the determination of the zenith point and of the errors of collimation, level, and azimuth.

The zenith point would be usually determined by the nadir observation of the middle Z.D. wire reflected in a mercury trough. In the meridian it would also be found from reflection observations of stars and the R—D correction deduced. The collimation error would be determined by the nadir observation of the reflected azimuth wire in reversed positions of the transit-circle. This would be checked by observations of collimators in the meridian, and also, perhaps, in the prime vertical, the collimators being mounted on either of two pairs of piers, in the meridian and prime vertical respectively.



The level error would be found by reflection from mercury (nadir observation). The azimuth may be determined by two observations of a circumpolar star, the co-latitude γ being

known. Thus, if P,Z in the figure be the pole and the zenith, S_1 S_2 the two positions of a circumpolar star when it is in azimuth $A' = A + a$, PM an arc perpendicular to ZS_2S_1 and bisecting S_1S_2 in M, the Z.D. z, at sidereal time t_1 (corresponding to S_1) and the Z.D. z_2 at sidereal time t_2 (corresponding to S_2) are observed, the observations being corrected for collimation and level and also, if necessary, for change of R.A. and N.P.D. in the interval $t_2 - t_1$.

Then

$$S_1PM = S_2PM = \frac{15}{2}(t_2 - t_1)$$

$$S_1M = S_2M = \tfrac{1}{2}(z_1 - z_2),$$

and the azimuth $A' = A + a$ is given by

$$\cos A' = \tan \tfrac{1}{2}(z_1 + z_2) \cot \gamma.$$

The N.P.D. and R.A. of the star are given by

$$\sin \Delta = \sin \tfrac{1}{2}(z_1 - z_2) \operatorname{cosec} \frac{15}{2}(t_2 - t_1)$$

$$\sin h_1 = \frac{\sin A' \sin z_1}{\sin \Delta}, \quad \sin h_2 = \frac{\sin A' \sin z_2}{\sin \Delta},$$

whence the R.A. α is

$$\alpha = t_1 + \frac{h_1}{15} \text{ or } t_2 + \frac{h_2}{15},$$

This method of determination of azimuth error (as well as of R.A. and N.P.D. of the star) is merely indicated above in general terms, without entering into details of computation.

The azimuth may, if necessary, be found from a single observation of a star if the N.P.D. and the co-latitude are known, or if the hour angle and star's N.P.D. or the co-latitude are known.

In cases where the motion in azimuth or zenith-distance is very slow, the azimuth or Z.D. micrometer may be used to bisect the star (with the middle wire), the instant of bisection being recorded on the chronograph, as in the case of close circumpolar stars with the transit-circle.

It will be seen from the foregoing explanation that such an instrument would be available to determine the R.A. and N.P.D. of the Sun, Moon, planets, and stars out of the meridian with the same accuracy as for a meridian observation, and with little more labour in calculation. The importance of extra meridian observations of the Moon was urged long ago by Sir G. B. Airy and has been generally recognised, and similar observations of the planets would also be of great value for the same reason, viz., the determination of positions in parts of the orbit where daylight prevents the observation of the object on the meridian or where the meridian observation would be some time after midnight, involving a long watch for the observer. The planet *Mercury* may be specially mentioned as an object for observation

out of the meridian, owing to the paucity of meridian observations.

The proposed instrument would also be available for the determination of refraction, latitude, and systematic errors of N.P.D. by comparison of observations of stars and the Sun in different azimuths, and this would, in my view, be a very important application of the instrument. It would, in fact, enable us to determine with the accuracy of a meridian observation the fundamental places of stars under different instrumental and observational conditions, and thus to give independent determinations available for the discussion of refraction, latitude, and systematic errors generally.

When fixed in the meridian, this instrument would be to all intents and purposes a transit-circle, and could be used for all the ordinary meridian observations. I would propose that it should have a telescope of 8 inches aperture and of about 8 feet focal length, with two circles of 3 feet diameter each read by four microscopes, and that the reversing apparatus should lift it sufficiently high to give a clear view for the collimators, without perforation of the central portion, which should be made barrel-shaped, instead of in the usual form of a cube. The object-end and eye-end of the telescope tube should be precisely similar as regards strengthening diaphragms, and the object-glass and eye-piece micrometer should be readily interchangeable, the mode of attachment to the tube being the same for both.

Royal Observatory, Greenwich:
1892 *May* 12.

Note on the History of the Great Sun-spot of 1892 *February.*

By E. W. Maunder.

(*Communicated by the Astronomer Royal.*)

Although it was not until the month of 1892 February that this Sun-spot first attracted general attention, this was not its first appearance, for it had been seen during the three preceding months. It was first seen so far back as 1891 November 15, and was not finally lost to sight until 1892 March 17. And as it took its first rise, and underwent final dissipation, whilst in the invisible hemisphere, it was thus watched through the whole of five semi-rotations.

It was only during the February appearance that the group reached exceptional proportions, but during each of the other four appearances it was an important group, and during November it was decidedly above the average of spots at the present time as to size, and showed many features of interest. But the most remarkable feature in its history was the striking and persistent drift in latitude which it exhibited from its first appearance in 1891 November up to the time of its greatest

development in 1892 February. The following measures are complete at present only for the months of 1891 November and December. As no photographs for 1892 have been received as yet from the Solar Physics Committee, and 1892 January and February were very cloudy, the Greenwich record is very defective during those two months. Photographs were only obtained on seven days during the January appearance of the group, on six days during the period of its observation in February, and on ten days during that in March. The results, though thus imperfect, will be sufficient to render obvious this most unusual movement.

1891 *November.*

The group was seen on thirteen days during this month, and on each day one or more photographs were taken either at Greenwich or at one of the two co-operating observatories, Dehra Dûn and Mauritius.

November 15. A large spot, about 400 millionths in area, is seen close to the east limb.

November 16. The group now consists of three spots: two nearly in the same longitude, but differing in latitude, the third following the other two by about 5° of longitude.

November 17. The two preceding spots of November 16 now appear to be coalescing. A few faint spots and an arch of bright faculæ unite these preceding spots to the one which follows.

November 18. The group has now assumed the form, so typical of the more important disturbances, of a long procession of spots of various sizes, of which the first and last are by far the most considerable.

November 19. Usually in such cases the leading spot becomes very sharply defined and nearly circular in shape, and this takes place eventually in the case of the leader of the present group, but it passes through some curious changes first. On this day it shows itself as a large and most beautiful spot, as it is intersected by an intricate network of bright bridges.

November 20. The leader seems to show a tendency to assume a symmetrical shape, but it is strongly elliptical, instead of being circular.

November 21. The small spots in the middle of the group have nearly all disappeared, whilst both the leading and the last spots have greatly increased in size; the leader lengthening out instead of tending to become more nearly circular.

November 22. The group now consists simply of two great spots; the leader very much elongated and intricate in shape; the following spot nearly circular and with very dark nucleus. The remarkable changes which the entire group underwent on these days were accompanied by a considerable magnetic disturbance; the needles showing a moderate amount of agitation from November $19^d\ 23^h$ (Greenwich Civil Time) to November $21^d\ 0^h$, and again after a short period of quiescence, from November $21^d\ 6^h$ until November $22^d\ 2^h$.

November 23. The group now begins to decline, the leading spot breaking up into a long chain of small spots, of which the leader, which is nearly circular in shape, is the best defined.

November 24. Of this chain of small spots, few except the leader now remain. The leader, however, has become larger and better defined, with a dark central umbra.

November 25. The group is again practically reduced to two spots, the smaller and fainter spots in the middle of the group having nearly all disappeared.

November 26. Only two spots now remain, and these are nearly of equal size. For the following spot of November 22 has been gradually diminishing in area whilst the preceding part of the group has been undergoing these remarkable changes.

November 27. The leader is now only seen as a shallow notch on the limb, too faint and shallow for accurate measurement, so that to a cursory view the following spot appears to be left alone.

The group was seen on the East limb on November 15, passed the central meridian on November $21^d\ 13\frac{1}{2}^h$ (Greenwich Civil Time), and reached the West limb on November 27.

Two small groups attended the great one during part of its course. Both were so near the great group as evidently to belong to the same general disturbance, and indeed the great spot of February was large enough to have included all the three groups of November within its area. Calling the group, the history of which we have just followed out, A, and these two minor groups B and C, the following notes briefly sum up their history.

Group B.

Appeared on November 15 as a scarcely perceptible pore, but was not seen on November 16. Reappeared on November 17, in advance of Group A in longitude, and on nearly the same

parallel of latitude. It was only a small and insignificant group during this rotation, but was seen also during December.

Group C.

First seen on November 20 as a fairly important group. It had nearly the same longitude as Group A, but was considerably nearer the equator. It shared in the great change of Group A on November 22 and 23. For whilst on November 22 Group C had all but disappeared, on November 23 it was seen as a chain of small spots completely enclosing a large rhomboidal area, greater than the largest spot of Group A. By November 24 Group C had taken the typical form of a chain of small spots, the leader of which was the largest, and the most regular in form, whilst the following members of the group were quite faint and small.

The following tables give the mean heliographic positions of the centres of the groups during their successive appearances, together with their areas, as projected, and as corrected for foreshortening, the former being expressed in millionths of the Sun's apparent disc, the latter in millionths of the visible hemisphere.

Group A, 1891 *November*.

Date. Greenwich Civil Time.				Longitude from Central Meridian.	Heliographic Longitude from Prime Meridian.	Latitude.	Projected Area.		Area corrected for foreshortening.	
	h	m	s	°	°	°	Umbra.	Whole Spot.	Umbra.	Whole Spot.
Nov.	15	3	9	−84·1	260·9	−16·8	0	66	0	401
	16	4	19	−69·0	262·2	−17·2	28	175	41	267
	17	5	44	−55·2	262·1	−17·9	58	321	56	305
	18	5	14	−44·0	260·3	−18·5	56	421	42	318
	19	7	20	−28·4	261·7	−18·9	141	817	88	493
	20	4	39	−17·6	260·7	−19·2	276	1369	156	773
	21	4	23	− 5·0	260·2	−19·4	327	1898	178	1029
	22	6	49	+ 9·5	260·3	−20·1	308	2115	171	1162
	23	4	33	+20·9	259·7	−20·1	270	1564	160	909
	24	5	14	+36·9	262·1	−20·9	208	1074	141	733
	25	10	23	+50·9	262·1	−20·5	70	1002	154	908
	26	11	35	+65·7	261·0	−20·1	63	456	81	609
	27	5	32	+78·7	264·2	−20·4	46	252	72	719
	Means			...	260·7	−19·1	...	...	103	634

Group B, 1891 *November*.

	h	m	s							
Nov.	15	3	9	−58°7	287°3	−20°1	0	2	0	2
	16	4	19	...	...	...	...	...	...	...
	17	5	44	−32·9	284·4	−18·4	0	11	0	7
	18	5	14	−19·5	284·8	−18·9	4	48	2	27
	19	7	20	− 8·1	282·0	−19·3	13	45	7	25
	20	4	49	+ 6·6	284·9	−19·1	35	115	19	62
	21	4	23	+18·2	283·4	−19·0	10	77	6	44
	22	6	49	+34·9	285·7	−18·2	0	96	0	59
	23	4	33	+45·5	284·3	−18·4	3	57	3	44
	24	5	14	+63·0	288·2	−18·5	0	16	0	18
	Means			...	285·0	−18·8	...	...	4	32

Group C, 1891 *November*.

	h	m	s							
Nov.	20	4	49	−16°8	261°5	−11°4	22	120	13	65
	21	4	23	− 4·0	261·2	−12·0	0	39	0	15
	22	6	49	+13·2	264·0	−11·9	0	41	0	21
	23	4	33	+24·4	263·2	−10·9	27	170	15	96
	24	5	14	+39·0	264·2	−11·1	46	315	30	207
	25	10	23	+57·7	266·9	−10·5	26	182	25	175
	26	11	35	+72·6	267·9	−10·7	12	57	20	96
	27	5	32	+83·4	268·9	−10·6	0	53	0	244
	Means			...	264·7	−11·1	...	...	13	115

1891 *December*.

Group A was first seen on December 12, crossed the central meridian on December 18^{d} 7^{h}, and reached the West limb on December 24. Its history during this appearance is soon told. It was a single well-defined circular spot, and it suffered very little change throughout the entire rotation.

Group B was not seen on December 12. It had not therefore persisted during the entire interval from its reaching the West limb on November 24, for had it done so it would have been seen on the East limb on December 11. But it soon formed again, and a very small spot was seen on December 13, two spots on December 15, and by December 16 the total area of the groups equalled that of the single spot which now represented Group A. On this day it showed a cluster of small spots in the preceding part of the group, and a large spot with a very dark umbra in the following part. The group had greatly increased in area by December 17, and from this time to the end of the rotation it was much larger than Group A. For the greater part of this period

it consisted chiefly of two circular spots, either of which was larger than the spot which made up Group A.

Group C did not reappear in this rotation, but was represented on December 12 by a bright group of faculæ.

Group A, 1891 *December*.

Date. Greenwich Civil Time.	Longitude from Central Meridian.	Heliographic Longitude from Prime Meridian.	Latitude.	Projected Area. Umbra.	Projected Area. Whole Spot.	Area corrected for foreshortening. Umbra.	Area corrected for foreshortening. Whole Spot.
h m s	°	°	°				
Dec. 12 5 15	−80·1	267·9	−19·8	11	45	32	135
13 5 36	−67·7	266·9	−19·7	18	107	25	147
14 7 39	−52·2	268·2	−18·9	31	146	27	127
15 5 3	−40·9	267·7	−20·0	38	194	27	136
16 4 50	−27·8	267·7	−20·0	41	200	25	120
17 11 59	−11·1	267·3	−19·3	36	276	19	148
18 4 43	− 1·3	267·9	−20·2	49	245	26	130
19 9 35	+14·7	268·1	−19·9	33	215	18	117
20 5 23	+28·5	267·5	−19·7	25	162	15	98
21 11 45	+41·8	267·7	−19·4	12	148	8	103
22 7 18	+52·7	267·9	−20·0	16	138	14	120
23 7 11	+63·7	265·8	−18·1	19	77	23	95
24 5 18	+77·6	267·5	−19·8	9	37	20	86
Means	...	267·5	−19·6	...	...	21	120

Group B, 1891 *December*.

h m s	°	°	°				
Dec. 13 5 36	−48·2	286·4	−18·6	0	13	0	11
14 7 39	−36·0	284·4	−17·7	0	3	0	2
15 5 3	−24·8	283·8	−20·1	0	47	0	28
16 4 50	−12·1	283·4	−20·0	56	200	28	99
17 11 59	+ 5·8	284·2	−19·1	134	715	71	376
18 4 43	+15·5	284·7	−19·8	161	742	88	408
19 9 35	+31·2	285·0	−19·2	117	871	72	534
20 5 23	+45·4	284·4	−18·7	46	548	33	404
21 11 45	+58·5	284·4	−18·3	39	394	39	390
22 7 18	+69·2	284·0	−19·0	20	218	27	315
23 7 11	+79·3	281·4	−18·2	12	52	35	157
Means	...	284·2	−18·9	...	...	36	248

1892 *January*.

The sun was photographed on only seven days at Greenwich during the January appearance of the group, and as no

photographs have as yet been received through the Solar Physics Committee from India or Mauritius, the daily record is still very incomplete. The group would appear to have crossed the central meridian on January $13^d\ 19^h$, and to have reached the West limb on January 21.

It is not quite clear whether the group represented Group A or Group B, or whether it represented rather the general disturbance of which those two groups were indications. There can be no doubt but that A and B both belong to the same general disturbance, but if the January group represented one of the two rather than the other, it will probably have corresponded to Group B, inasmuch as it was moving in the direction of decreasing longitude throughout January, and its longitude was greater than that of A, but less than that of B.

The group on January 7 consists of a single large, well-defined spot. On January 8, when it has come further on the disc, some faint smaller spots are seen following it, and a small spot is seen to the north which appears to correspond to the Group C of the November appearance. By January 12 these faint companions of the principal spot have nearly disappeared, and on January 13, 14, and 16 the principal spot was seen alone. But a very striking change had occurred by January 20, for on that day the group consists of two large, well-defined spots, with a number of small spots connecting them. The imperfection of the record, owing to cloudy weather on January 17, 18, and 19, renders it impossible to say at present when and how this change took place.

Group B, 1892 *January*.

Date. Greenwich Civil Time.				Longitude from Central Meridian.	Heliographic Longitude from Prime Meridian.	Latitude.	Projected Area. Umbra.	Projected Area. Whole Spot.	Area corrected for foreshortening. Umbra.	Area corrected for foreshortening. Whole Spot.
	h	m	s	°	°	°				
Jan.	7	9	44	−81·2	281·0	−24·7	0	50	0	144
	8	10	26	−67·4	282·1	−24·6	33	172	45	229
	12	9	38	−18·5	278·8	−24·7	36	331	36	191
	13	10	6	− 4·8	279·1	−24·5	41	347	22	185
	14	9	37	+ 8·0	278·9	−25·3	49	387	26	207
	16	11	49	+34·1	277·5	−25·7	30	296	19	189
	20	11	30	+77·0	267·9	−25·5	112	683	205	1404
	Means			...	278·0	−25·0	...	...	50	364

1892 *February*.

Photographs were taken at Greenwich only on six days during the February appearance of the great group. On February 4 the first outliers of the group made their appearance at the East limb. On February 5 the great spot itself was seen. A period of cloudy weather then set in, and the next photograph was not taken till February 13. The group was then seen in its

full magnificence as the largest ever photographed since the beginning of the Greenwich record. The extreme length of the group was 25° of solar longitude, and that of the great spot 14°; the greatest breadth of the entire group was 10° of solar latitude and of the spot 8°. A very considerable group, apparently corresponding to group C, lay a little to the north. The great group much resembled in its chief characteristics the great groups of April and November, 1882. Instead of a number of spots tending to stretch themselves out into a long line, and the principal members of which tend to assume the circular form, which is the arrangement typical of most considerable groups, these three great groups showed each one great irregular spot in the centre of the group, in contradistinction to the more general type, in which the chief spots are found either at the beginning or end of the group. Then these great spots each contained a number of distinct nuclei within their borders, nuclei wholly and entirely separate from each other, and not merely fragments of one nucleus cut up in appearance only by overlying bright bridges. No important change in character was noted during the succeeding days, though there was a marked diminution in area. Group C was of the usual type—a chain of spots of which the first and last were the most considerable. The spots in the middle of the group tended to die out as usual, the only departure from the normal behaviour being that in the course of events both the first and last spots were provided with a considerable companion, and the group reached the limb as a pair of close pairs. The Great Group crossed the central meridian, February $12^d\ 2^h$.

Group B, 1892 February.

Date. Greenwich Civil Time.	Longitude from Central Meridian.	Heliographic Longitude from Prime Meridian.	Latitude.	Projected Area. Umbra.	Projected Area. Whole Spot.	Area corrected for foreshortening. Umbra.	Area corrected for foreshortening. Whole Spot.
h m s	°	°	°				
Feb. 4 10 49	−88·4	264·4	−26·4	0	25	0	250
5 10 25	−81·6	259·3	−28·8	77	1144	96	1524
13 9 47	+17·3	253·1	−27·3	952	6274	536	3528
16 9 40	+56·2	252·6	−26·5	331	2919	300	2670
17 12 10	+69·0	250·9	−27·4	122	1249	161	1683
18 11 58	+80·8	249·6	−28·8	35	635	98	1605
Means	...	255·0	−27·5	...	...	198	1877

Group C, 1892 February.

Feb.	13 9 47	+ 3·7	239·5	−19·4	164	1022	85	529
	16 9 40	+42·0	238·4	−19·6	66	559	44	382
	17 12 10	+57·1	239·0	−20·1	24	274	22	250
	18 11 58	+69·5	238·3	−20·1	6	159	14	216
	Means	...	238·8	−19·8	...	...	41	344

1892 *March.*

Photographs were taken at Greenwich on ten days during this appearance, the group being first seen on the East limb on March 4. It had undergone a very great diminution in size since February, its area on March 4 being only 158 millionths, as against the 3528 millionths of February 13. It, however, steadily increased in size till it reached the central meridian on March $10^d\ 10^h$, small spots forming both in advance and behind the principal spot, and tending to coalesce with it. By March 12 the group consisted of a large spot followed by a train of small faint spots. By March 14 the leader showed signs of dividing into two nearly equal portions, and by March 16 the division had been completely accomplished. It is interesting to note that Group C appeared to be represented on March 16 by a pair of small spots, though no spots were visible in that region during the earlier part of the rotation.

Group B, 1892 *March.*

Date. Greenwich Civil Time.	Longitude from Central Meridian.	Heliographic Longitude from Prime Meridian.	Latitude.	Projected Area. Umbra.	Projected Area. Whole Spot.	Area corrected for foreshortening. Umbra.	Area corrected for foreshortening. Whole Spot.
h m s	°	°	°				
Mar. 4 11 30	−84·6	249·9	−28·8	0	44	0	158
5 9 51	−70·3	249·0	−28·5	20	147	28	208
7 9 54	−45·6	247·2	−28·5	46	716	34	813
8 10 39	−28·9	250·4	−29·0	57	856	35	521
10 11 48	+ 1·1	253·4	−27·7	163	1192	87	640
11 9 22	+10·0	250·4	−28·9	80	639	45	358
12 11 9	+24·8	251·1	−28·1	99	802	60	475
14 10 13	+51·7	252·2	−28·3	53	350	4	293
16 11 4	+75·2	248·8	−27·7	44	243	44	243
17 11 2	+87·0	247·4	−28·4	5	37	24	178
Means	...	250·0	−28·4	...	...	40	389

Group C, 1892 *March.*

Mar. 16 11 4	+63·5	237·1	−23·4	0	27	0	30
17 11 2	+76·5	236·9	−23·8	3	32	5	61
Means	...	237·0	−23·6	...	...	3	46

It may be interesting to add that though the great group did not return again, yet that during April a circular spot was seen in about the same longitude and in the same latitude as that in which group C had originally appeared, so far back as 1891 November. Later still a very considerable group has been seen

during the last days of April, and the early days of May, in almost exactly the latitude occupied by the great group during the January appearance, and in almost the same longitude as it occupied in March, whilst an examination of earlier photographs in 1891 has shown two evanescent little groups on September 27 and October 25, in the precise region which was the seat of the first appearance of the group in November last. The entire region, therefore, has been the seat of strong, intermittent, and repeated disturbance.

On a Pretended Early Discovery of a Satellite of Mars.

By Ralph Copeland, Ph.D.

In the Crawford Library of the Edinburgh Royal Observatory is a quarto pamphlet of ten leaves, the complete title of which is: "Eberhard Christian Kindermanns, Königl. Pohl. und Churfürstl. Sächszl. Hof-*Math.* und *Astronomi*, ASTRONOMISCHE BESCHREIBUNG und NACHRICHT von dem COMETEN 1746. Und denen noch kommenden, welche in denen innen besagten Jahren erscheinen werden.—Dreszden, zu finden bey Gottlob Christian Hilschern, Hof-Buchhändler, 1746." Although Kindermann* thus held the post of astronomer to the King of Poland, who was at the same time Electoral-Prince of Saxony, the few observations he has placed on record have hitherto proved of very little value. Doubts, indeed, have at various times been expressed as to their general trustworthiness; nor is it quite certain that the comet of which the little book under consideration professes to treat ever really existed, although Kindermann gives the names of two persons and mentions a third by whom he alleges it to have been seen, as well as by himself. Dr. Hind, however, has succeeded in deriving a rough orbit from the fuller particulars given by Struyck, to whom Kindermann had communicated them. The tract also contains predictions of the return of three several comets, amongst them that of 1661, of which the elements, computed long previously by Halley, resemble those of the comet of 1532. Probably it was this resemblance which led Kindermann to assume their identity with a period of 129 years and a consequent return in 1790, a conjecture which, it is needless to say, was never realised.

These particulars are now of little moment, except in so far as they characterise the writer of the book, the frontispiece of which is sufficiently striking, containing, as it does, a little figure professing to show the orbit of a satellite of *Mars* discovered by the author. The encircling legend runs: "Via Luna (*sic*) Martis entdecket vom Autore den 10. Iul: 1744." On

* The Pulkowa Library contains three of his books, including the one described above.

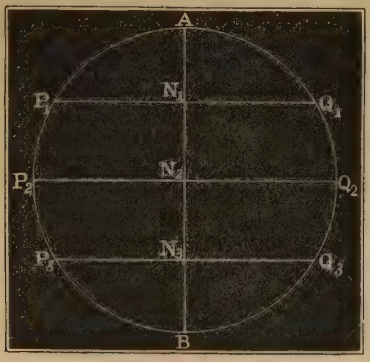
the face of the planet are various distinct markings, amongst which it is easy to recognise the long "dumb-bell," drawn by Divini and Cassini, and figured in the first volume of the *Philosophical Transactions*. The satellite is only removed about $2\frac{1}{2}$ radii of *Mars* from the centre of the planet. The satellite is nearly four-tenths of the diameter of the primary, and both bodies are liberally provided with atmospheres.

It may be mentioned that *Gulliver's Travels* were given to the world in 1726–7, while Voltaire's *Micromégas* seems to have been published about 1752. The statements they contain about the moons of *Mars* are widely known through Professor Hall's memoir. Kindermann's "discovery" is thus intermediate, in point of date, between the felicitous conceptions of the great satirists.

On the Illumination of Saturn's Rings during Sunrise; and on recent Observations of their Reappearance. By the Rev. A. Freeman.

In order to ascertain the significance of the American and European observations made in 1891 October and November, near the time when the Sun's centre was in the plane of *Saturn's* Rings, I have investigated expressions for the intensity of light cast by the Sun upon the rings, at the four stages when, to an observer at *Saturn's* centre, one-fourth, one-half, three-quarters, and the whole of the Sun's diameter has risen above the plane of the rings. Adopting the method given by Sir J. Herschel in the article on *Light* (*Encyc. Metrop.* § 44 sqq.) or in Parkinson's *Optics*, § 42; if with vertex at the centre of the rings, we draw a cone whose generators touch the spherical surface of the Sun, and consider the boundaries of the section of a hemisphere radius unity, concentric with the rings, intercepted between the cone and the plane of the rings; and if we project this intercepted surface orthogonally upon the plane of the rings, we have an exact representation of the intensity of Sun-light received upon unit area at the centre of the ring-plane. Moreover, if 2θ be the circular measure of the apparent diameter of the Sun as seen from *Saturn*, the intensity thus measured will be of the order θ^3, and will differ in fact from the average intensity of the whole ring by a term of the order $\frac{a^2}{\rho^2}\theta^4$, in which $\frac{a}{\rho}$ is the circular measure of the radius of the ring as seen from the Sun, *i.e.*, the circular measure of about $20''{\cdot}2$, and θ is the circular measure of about $102''{\cdot}3$. This small term may evidently be neglected. The surface of the rings is not truly plane, but an increase of brightness of any element of the surface will be balanced by a corresponding decrease on an opposite element, and so the average illumination of the whole surface will not be affected by the deviation from a plane.

In the annexed figure the circle represents the section of the hemisphere by the cone when the Sun has wholly risen. P_1Q_1, P_2Q_2, P_3Q_3, are the sections of this circle by the ring's plane when $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ of the Sun's diameter has risen.



1. If the radius of the hemisphere be unity, the radius of the circle will be sin θ and its area $\pi \sin^2\theta$, projected at an inclination $\frac{\pi}{2} - \theta$ upon the ring's plane the intensity of illumination for the Sun just wholly risen is measured by $\pi \sin^3\theta$.

2. When the diameter P_2Q_2 is on the ring's plane, the projected area is the segment of a circle radius unity bounded by a chord equal to 2 sin θ, its value is

$$\theta - \sin\theta\cos\theta, \text{ or } \tfrac{2}{3}\theta^3 \text{ nearly.}$$

3. When P_1Q_1, which is equal to

$$2\sqrt{1 - \cos^2\theta \cdot \tan^2\frac{\theta}{2}}$$

is upon the ring-plane, *i.e.*, when the altitude of A

$$\text{is } \frac{\theta}{2},$$

and

$$N_2N_1 = \cos\theta \cdot \tan\frac{\theta}{2}$$

the projected area is the *difference* between a circular segment and an elliptic segment having the same chord P_1Q_1, its value is equal to

$$2\int_{\cos\theta \cdot \sec\frac{\theta}{2}}^{1} \sqrt{1 - x^2} \cdot dx - 2\sin\frac{\theta}{2}\int_{\cos\theta \cdot \tan\frac{\theta}{2}}^{\sin\theta} \sqrt{\sin^2\theta - x^2} \cdot dx$$

Evaluated by the method of limits when θ is small, the value is

$$\left(\frac{3\sqrt{3}}{8}-\frac{\pi}{6}\right)\theta^3$$

4. When P_3Q_3 ($=P_1Q_1$) is upon the ring-plane, *i.e.*, when the altitude of A is $\frac{\theta}{2}$, and $N_2N_3=N_2N_1$, the projected area is the *sum* of a circular segment and an elliptic segment (greater than half the ellipse) having the same chord P_3Q_3; its value may be derived from the last from the consideration that the *difference* between it and the last area is the ellipse formed by projecting the circle $\pi \sin^2\theta$ at an inclination of $\frac{\pi}{2}-\frac{\theta}{2}$, *i.e.*,

$$\pi \sin^2\theta \,.\, \sin\frac{\theta}{2} = \tfrac{1}{2}\pi\theta^3 \text{ nearly.}$$

Hence the area we require is

$$\left(\frac{\pi}{2}+\frac{3\sqrt{3}}{8}-\frac{\pi}{6}\right)\theta^3, \text{ or } \left(\frac{\pi}{3}+\frac{3\sqrt{3}}{8}\right)\theta^3.$$

The intensities of the illumination of the ring-plane by the Sun are in the four stages proportional to

$$\left(\frac{3\sqrt{3}}{8}-\frac{\pi}{6}\right),\ \tfrac{2}{3},\ \left(\frac{\pi}{3}+\frac{3\sqrt{3}}{8}\right),\ \pi.$$

that is to say, as

$$0{\cdot}12592 : 0{\cdot}66667 : 1{\cdot}69672 : 3{\cdot}14159,$$

or nearly, as

$$4 : 21 : 54 : 100.$$

Now the Sun's diameter at the mean distance from the Earth is $32'\ 3''{\cdot}64$ and on October $30^d\ 12^h$ G.M.T. (astro.), which I shall show to be the date given by Bessel's corrected formula for the hour when the Sun's centre was in the ring-plane, the logarithm of *Saturn's* heliocentric distance was 0·9744038. Hence, if x be the Sun's semi-diameter in seconds of arc, as seen from *Saturn* at this date,

$$L_{10}\sin x = L_{10}\sin 16'\ 1''{\cdot}82 - 0{\cdot}9744038,$$

whence

$$2x = 3'\ 24''{\cdot}66 = 204''{\cdot}66 = \text{Sun's diameter.}$$

But in the ten days between October 26 and November 5 the change of the Sun's altitude relative to the ring-plane was $0°{\cdot}154$ according to Mr. Marth's ephemeris, or $55''{\cdot}44$ daily; and consequently the time required for the Sun's diameter to cross the ring-plane is

$$\frac{204''{\cdot}66}{55''{\cdot}44}\,.\,24^h = 88^h{\cdot}19 \text{ nearly.}$$

Each of the four stages of sunrise follows its predecessor by 22 hours very nearly. The altitude of the Earth above the ring-plane differs very little from 2°5′ during the 88 hours, its change is only to the extent of about 1 per cent. in 22 hours. Hence, the light received from the ring by an observer on the Earth will not differ appreciably from the proportions

4 : 21 : 54 : 100,

corresponding to the four stages of sunrise.

In addition to the observations reported by Mr. Barnard at Mount Hamilton, Mr. Comstock at Madison, Professor Oudemans at Utrecht, and by myself near Sittingbourne, all of which are published in the current volume of the *Monthly Notices*, I should wish to refer to the observation made by M. Léon Guiot at Soissons, France, October 30^{d} 18^{h} (*Astro. M.T.* of Paris), on which occasion he saw the ring represented by a fine line extending only one-eighth of the equatorial diameter of *Saturn* beyond the following limb (*L'Astronomie*, 1892 January). M. Guiot has informed me by letter that "on the following morning the ring was visible on both sides thin and long." This is a valuable confirmation of the momentary observation at Utrecht 40 minutes earlier. M. Guiot in his letter says that the instrument employed was a refractor of 10 centimetres aperture magnifying 150 times. It is probably the same as that which he used to observe the conjunction of ♅ and ♀ 1892 February 6, and which is stated more exactly to have an aperture of 95 m.m., or $3\frac{3}{4}$ inches (see *L'Astronomie*, 1892 March).

Recording the observations in order of G.M.T. (astro.) we have to nearest 5^{m}.

October 29^{d} 17^{h} 10^{m}, *Oudemans* ($10\frac{1}{4}$in. O.G.) Clear. *Saturn* decidedly without ring. Confirmed by myself with 6in. O.G. 45^{m} later.

October 30^{d} 1^{h} 5^{m}, *Barnard* (36in. O.G.) The rings were easily and distinctly visible as slender threads of light.

October 30^{d} 17^{h} 50^{m}, *Guiot* ($3\frac{3}{4}$in. O.G.) A fine bright line followed the East limb to a distance of only $\frac{1}{8}$ diameter of *Saturn*.

October 30^{d} 23^{h} 15^{m}, *Comstock* ($15\frac{3}{4}$in. O.G.) Rings plainly visible as continuous lines, extending on each side $\frac{3}{5}$ diameter of ball.

October 31^{d} 17^{h} 10^{m}, *Oudemans* ($10\frac{1}{4}$in. O.G.) Clouds. *Saturn* visible for a moment; at both sides the ring is visible as a thin bright line. Confirmed by Guiot with $3\frac{3}{4}$in. 40^{m} later.

November 1^{d} 17^{h} 30^{m}, *Freeman* (6in. O.G.) Bright blue ansæ seen on both sides of *Saturn* to a distance about $\frac{5}{8}$ of his diameter.

There can be no doubt that the great telescope of Mount Hamilton would exhibit the rings in the first stage of illumina-

tion rather more easily than the telescope I used would do so in the fourth stage, the *areas* of the object glasses being as 36 : 1, and the quantities of light from the rings as 1 : 25. It will be noticed that the interval of time between Mr. Barnard's observation and my own is $64^h\ 25^m$, whilst the interval between the first and fourth stages is 66^h. Again, the interval between Mr. Comstock's observation and my own is $42^h\ 15^m$, whilst the interval between the second and fourth stages is 44^h; in this case, too, the areas of the object glasses are as 7 : 1, and the light received as 1 : 5 nearly.

I am inclined to think that Mr. Comstock's observation was made at a point of time near to the instant when the centre of the Sun was in the plane of the rings; and that the Sun was almost if not quite fully risen above the plane of the rings when I saw the ansæ. Further observations from Observatories in Europe and Australia will, it may be hoped, yet be published, and contribute to determine the place of the node of the ring upon the ecliptic. I am decidedly of opinion that the appearances seen by Mr. Comstock and Mr. Townley, October 20, 25, 26, 27, are either views of the illuminated edges of the rings and of their principal divisions, when the Sun and Earth were on opposite sides of the rings, according to Bond's explanation in *Annals of Harvard Observatory*, vol. ii., Part I., pp. 118–120; or else, if G. A. Hirn's hypothesis be adopted, viz., that the rings are composed of separate satellites, *each with an atmosphere of its own*, revolving in circular orbits in planes inclined at diverse angles within small limits to the equator of *Saturn*, then the appearances seen at Washburn Observatory (previous to the real reappearance of the ring-plane caused by the beginning of actual sunrise) may have arisen from the light of the Sun being diffused through the interstices of this infinite number of satellites *by means of their atmospheres*, thereby giving a feeble illumination to that side of the ring-plane which was presented to the Earth. It is strange that no other observer but myself has stated the colour of the rings when first seen. This deficiency may yet be made good. To assist in the future discussion of the problem, I will add that the formulæ of Bessel, corrected by insertion of the truer values of δi, δn, and m, as found by Professor Oudemans (*Monthly Notices*, vol. xlix., p. 57), are

$$n = 167^\circ\ 18'\ 41''{\cdot}9 + 46''{\cdot}473\,(t-1833)$$
$$\iota = 28^\circ\ 10'\ 32''{\cdot}1 + 0''{\cdot}351\,(t-1833),$$

and for 1891 October $30^d\ 12^h = 1891{\cdot}8282$

$$n = 168^\circ\ 4'\ 15''{\cdot}85, \quad \iota = 28^\circ\ 10'\ 11''{\cdot}45.$$

the change in one day or 0·0027 of a Julian year is unimportant. The *Nautical Almanac* gives for *Saturn*,

October $30^d\ 0^h$, Helioc Long. 172° 3′ 43″·0, Lat. 2° 8′ 34″·9.
October $31^d\ 0^h$, Helioc Long. 172° 5′ 46″·2, Lat. 2° 8′ 37″·6.

and upon the *hypothesis* of the node of the ring-plane on the ecliptic passing through the Sun's centre at either of these dates, the value of i being taken as on October $30^d\ 12^h$, we shall find for the longitude of the node corresponding to

October $30^d\ 0^h$.....168° 3′ 18″·1.
October $31^d\ 0^h$.....168° 5′ 16″·2.

from which it will appear that the value given by the formula of Bessel as corrected corresponds to October $30^d\ 11^h{\cdot}75$.

In conclusion, I may say that the most probable reasons for my not having seen any trace of the rings, October $30^d\ 18^h$, are (1) that I observed too short a time before sunrise, (2) that definition that morning was not nearly so good as on the two days previous, fewer belts being seen on the planet. The observations of Mr. Barnard and Mr. Comstock seem to have been made 81^m and 76^m before sunrise to them.

Murston Rectory, Sittingbourne:
1892 May 7.

Negatives of Jupiter, made with the Great Telescope of the Lick Observatory during 1891. By Edward S. Holden and W. W. Campbell.

We have the honour to present to the Royal Astronomical Society, in the name of the Lick Observatory, a series of negatives of *Jupiter*, made with the Great Telescope during the year 1891, in continuation of the work of 1890. A list of the negatives is given below. The following memoranda should accompany them. The negatives are all taken on 8 × 10 plates—Seed, No. 26. The enlargements are directly made, in the telescope, by means of an ordinary camera objective of 2 inches aperture and 14 inches focus, furnished us by Alvan Clark, Jun., for the purpose. This lens is used so as to give an enlargement of a little over eight diameters—that is, the negatives are affected by the wind blowing on the instrument (and by other accidental disturbances) as if they were taken in the principal focus of a telescope 400 feet long.

The enlargement employed is too great, and the enlarging lens itself is not entirely satisfactory. We hope to procure a new lens before the next opposition, which shall give better images and less magnifying.

All the exposures have been made by the two observers working together, and all the plates have been developed by Mr. Campbell. Each plate is intended to be marked with the date, the observers' initials, the setting of the enlarging lens in its tube (5·06), the setting of the negative plate on the focusing screw (1·0), the Pacific standard times of the beginning and

ending of each exposure, with notes on the weather. In these notes the words "Windy" and "Very windy" are far too common. The exposures varied between eight and twelve seconds, ten seconds being the usual one.

Several negatives were made each night, and the best have been selected and are preserved for reference at the Lick Observatory. All the other plates were called "duplicates," and as full a set of these as possible has been made up for presentation to the Royal Astronomical Society, irrespective of the excellence of the individual pictures. We desire to call attention to this fact, as our object has been to enable others to have all the data available for a study of the planet, and not at all to exhibit only the best results of our work. Even the poorest pictures have a statistical value. We have satisfied ourselves that when the atmospheric conditions are good (and especially when no wind is blowing) we can always produce results of uniform excellence. The number of pictures made in 1891 is smaller than it ordinarily will be, because the telescope was in use for making visual observations on the forms and the rotations of *Jupiter's* satellites on many of the nights which would otherwise have been devoted to photographic work.

Mount Hamilton:
1891 *December* 31.

List of Negatives of Jupiter.

Date 1891.	Name of Plate.	Number of Images on the Plate.	Approximate P.S.T. h m	Remarks.
Aug. 25	A^2	4	12 29	
26	B^2	4	11 48	
Sept. 28	G^2	3	10 34	Very windy.
28	F^2	3	10 43	Very windy.
28	C^2	3	11 54	Very windy.
Oct. 11	H^2	3	9 0	
11	G^1	3	10 8	
11	I^2	3	11 7	Windy.
12	B^2	3	8 57	Windy.
25	A^2	3	8 56	Windy.
25	H^1	3	9 40	Windy.
25	I^1	3	11 17	Windy.

Photographic Search for a Planet beyond the Orbit of Neptune.

By Isaac Roberts, F.R.S.

The hypothesis that one or more planets exist beyond the orbit of *Neptune* has been long entertained by astronomers, and Professor Forbes, in a remarkable paper on "Comets and ultra-Neptunian Planets," which he read before the Royal Society of Edinburgh at the beginning of the year 1880, predicted with considerable confidence that one or two such planets exist, and in the paper referred to he gave very fully his reasons.

The prediction was based upon the recorded positions of the aphelia of a number of comets. He said,* "That there could be no longer a doubt but that two planets revolve in orbits external to that of *Neptune*, one about 100 times, the other about 300 times the distance of the Earth from the Sun."

In 1887, November, I wrote to Professor Forbes to ask him if he had further considered the hypothesis concerning the supposed planets, and that I was prepared to make a search for them by photographic methods. In his reply he stated that the present position of one of the hypothetical planets is $11^h\ 48^m$ R.A. and 3° N. Declination, and he believed that a range of 5° each way in R.A. and of 2° or 3° in Declination ought to find the planet if it is there. The motion of the planet he computed at one degree in 2·96 years.

I thereupon commenced the search, but soon found that the climate of Maghull was so unfavourable for celestial photographic work of this character that my task was nearly hopeless; but since the removal of my observatory to Crowborough I resumed the search under conditions sufficiently favourable to complete the work, which was conducted on the following plan:—

A chart was made of the region indicated by Professor Forbes between R.A. $11^h\ 24^m$ and R.A. $12^h\ 12^m$ with Declination 0° 0′ to 6° 0′ North. This region was covered by eighteen photographic plates, each of more than four square degrees in area, and allowed of sufficient overlap to show a number of the same stars on two or more contiguous plates. Two sets of photo-plates of the region were taken with an interval of not less than seven days between the exposures, which were of ninety minutes duration, and the dual photographs were subsequently compared three times over by superposition, in order to see if any star appeared on one plate which was not on the other, or to see if change in the position of any star had taken place in the interval between the dual exposures. In this way the whole of the plates covering the region were very carefully examined, and it now only remains for me to report that no planet of greater brightness than a star of the 15th magnitude

* *Memoir*, p. 3.

exists on the sky area herein indicated, nor is there on the plates any abnormal appearance to which it is necessary here to draw special attention. It is a region where the stars are not exceptionally numerous, and they are mostly faint.

Crowborough Hill, Sussex:
1892 *April* 12.

Photographs of the Region of the "Crab" Nebula, 1 *M Tauri.*

By Isaac Roberts, F.R.S.

Two photographs of the region of the nebula 1 M *Tauri*, R.A. $5^h\ 29^m$, Dec. 21° 57′ N., are now presented, which have been enlarged from a negative taken with the 20-inch reflector on 1892, February 2, and exposure of three hours. One of the enlarged photographs is to the scale of one centimetre to four minutes of arc, and covers a sky area of ninety-two minutes of arc in Right Ascension by 112 minutes in Declination. The other photograph is enlarged to the scale of one centimetre to forty seconds of arc, and covers an area of nine minutes in diameter. The nebula measures 340 seconds of arc in extreme length by 260 seconds in breadth, and I counted sixteen stars involved in it.

The nebula is not symmetrical in form, and has a faint, undefined, boldly indented margin, with a large projecting limb on the south preceding side. It is oval in general outline, with the major axis in south following and north preceding direction, and on the north following side is a large deep embayment with little nebulosity in it, and there is also a smaller bay, but with nebulosity partly filling it. The negative shows dense massive cloudiness in parts of the nebula, with fainter areas between them, but they are too dense to print so as to be visible in detail on the enlargements.

I have not seen any drawing of this nebula that conveys even approximately an idea of its form as it is shown on the photograph, and there is no indication of the filamentous projections that are shown on some drawings, and which, if they had a real existence, would undoubtedly be shown.

The stars in the region of the nebula are very numerous, and when viewed on the negative the eye readily arranges them into festoons and wreaths of many patterns, but an enlargement, even to three and a half times, in great measure modifies this effect of perspective, which a larger magnifying power would dissipate.

On the Orbit of γ Coronæ Australis. By J. E. Gore.

Recent measures of the position-angle of this well-known southern binary star show clearly that the distance is now slowly but steadily increasing, and that the period will prove to be considerably longer than has been hitherto supposed. I find that the period given in my paper in the *Monthly Notices* for January 1886 is much too short, and the elements there given do not represent recent measures satisfactorily either in angle or distance. I have therefore re-computed the orbit by the Glasenapp-Kowalsky method, using all available measures, and now find the following provisional elements :—

Elements of γ Coronæ Australis.

P = 154·41 years	$\Omega = 77^\circ\ 14'$
T = 1876·84	λ = 175 17
$e = 0{\cdot}4244$	$a = 2''{\cdot}55$
$i = 35^\circ\ 35\frac{1}{2}'$	$\mu = -2^\circ{\cdot}3314$

The following is a comparison between the measures and the positions computed from the above elements :—

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
		°	°	°	″	″	″
1834·47	Sir J. Herschel	37·1	38·0	−0·9	...	2·81	...
1835·55	„	36·8	36·4	+0·4	...	2·77	...
1836·43	„	34·5	35·1	−0·6	...	2·73	...
1837·43	„	32·7	33·6	−0·9	2·66	2·68	−0·02
1847·32	Jacob	14·1	15·0	−0·9	2·30	2·20	+0·10
1850·46	„	5·9	7·2	−1·3	2·29	2·05	+0·24
1851·54	„	4·5	4·4	+0·1	2·26	1·99	+0·27
1852·49	„	2·2	1·6	+0·6	1·9	1·95	−0·05
1853·52	„	359·0	358·5	+0·5	1·83	1·90	−0·07
1854·26	„	356·2	356·2	0·0	1·71	1·87	−0·16
1856·44	„	349·4	348·8	+0·6	1·67	1·78	−0·11
1857·44	„	347·4	345·2	+2·2	1·61	1·74	−0·13
1858·20	„	343·4	342·4	+1·0	1·53	1·71	−0·18
1859·72	Powell	338·1	336·4	+1·7	1½ est.	1·66	...
1861·69	„	328·8	328·1	+0·7	...	1·60	...
1862·27	„	325·5	325·6	−0·1	1½ est.	1·58	...
1863·84	„	318·1	318·3	−0·2	...	1·56	...
1870·19	„	286·9	287·4	−0·5	.	1·47	...
1875·65	Schiaparelli	257·4	259·6	−2·2	1·45	1·46	−0·01

Epoch.	Observer.	θ_o	θ_c	$\theta_o-\theta_c$	ρ_o	ρ_c	$\rho_o-\rho_c$
1876·65	Howe	253°·1	254°·4	−1°·3	1″·67	1″·46	+0″·21
1877·43	Schiaparelli	248·4	250·4	−2·0	1·49	1·46	+0·03
1877·61	Howe	245·7	249·4	−3·7	1·37	1·46	−0·09
1877·69	O. Stone	249·4	249·0	+0·4	...	1·46	...
1878·49	„	242·4	244·8	−2·4	1·22	1·45	−0·23
1878·49	Howe	242·9	244·8	−1·9	1·47	1·45	+0·02
1879·69	Burnham	240·0	238·4	+1·6	0·87	1·44	−0·57
1880·46	Russell	233·1	234·3	−1·2	1·15	1·44	−0·29
1880·67	Hargrave	232·4	233·2	−0·8	1·32	1·44	−0·12
1881·72	O. Stone	225·5	227·6	−2·1	1·38	1·44	−0·06
1883·62	Wilson	217·7	217·4	+0·3	1·62	1·44	+0·18
1886·586	Pollock	200·3	201·5	−1·2	1·34	1·46	−0·12
1886·704	Russell	203·5	200·9	+2·6	1·52	1·46	+0·06
1886·705	Pollock	201·3	200·9	+0·4	1·68	1·46	+0·22
1887·689	„	196·6	195·8	+0·8	1·16	1·48	−0·32
1887·715	Tebbutt	196·7	195·7	+1·0	1·68	1·48	+0·20
1887·767	„	194·7	195·4	−0·7	...	1·48	...
1888·307	„	192·4	192·6	−0·2	1·59	1·49	+0·10
1888·637	„	187·9	190·9	−3·0	1·77	1·49	+0·28
1888·707	Leavenworth	188·0	190·6	−2·6	1·2	1·49	−0·29
1888·805	Tebbutt	191·9	190·1	+1·8	...	1·49	...
1889·41	Burnham	185·4	187·1	−1·7	1·79	1·50	+0·29
1889·843	Tebbutt	185·4	184·9	+0·5	...	1·51	...
1890·531	„	...	181·7	...	1·62	1·54	+0·08
1890·542	„	184·2	181·6	+2·6	...	1·54	...
1890·575	„	...	181·5	...	1·635	1·54	+0·095
1890·709	„	180·7	180·9	−0·2	1·54	1·54	0·0
1891·635	„	180·1	176·5	+3·6	1·57	1·57	0·0
1891·673	„	176·7	176·3	+0·4	...	1·57	...
1891·742	„	...	176·0	...	1·52	1·57	−0·05
1891·749	„	175·4	176·0	−0·6	...	1·57	...

According to the above orbit, the distance between the components will increase continuously during the next sixty years up to a maximum of about 3″·6.

Assuming that the mass of the system is equal to the mass of the Sun, the "hypothetical parallax" would be

$$p=\frac{a}{P^{\frac{2}{3}}}=0''\cdot088.$$

On the Orbit of γ Centauri. By J. E. Gore.

The measures of this southern binary star appear at first sight rather discordant. A closer examination, however, shows that the companion is revolving in a very elongated apparent ellipse, the real orbit being not only highly inclined to the line of sight but having a considerable eccentricity. I find that a complete revolution has been nearly performed since the star was measured by Sir John Herschel at the Cape in the years 1835 and 1836. Herschel's measures are somewhat discordant, ranging from 346·8 to 361·97; but measures in recent years show that if the position-angle was anything near 360° in 1835 and 1836, the distance between the components would have been nearly 2″, and they would have been easily divided with the 5-inch refractor used by Herschel. He estimated the distance, however, at only 0″·75, and says in the notes to his measures, "At least as close as γ *Virginis*; 273 barely elongates it . . . far too difficult for this telescope . . . excessively close and difficult." These remarks show that the distance could not have been anything like 2″ when Herschel measured it, and hence the position-angle must have been less than 360°, the motion being retrograde and not direct as Herschel supposed.

I have computed the orbit by the Glasenapp-Kowalsky method, and find the following provisional elements:—

Elements of γ Centauri.

P = 61·88 years	$\Omega = 177^\circ\ 57'$
T = 1840·84	$\lambda = 46\ 49$
$e = 0{\cdot}6316$	$a = 1''{\cdot}50$
$i = 84^\circ\ 6'$	$\mu = -5^\circ{\cdot}817$

P and T have been deduced from Herschel's measure at the epoch 1835·89, and Pollock's in 1889·323. The measures from 1856 to 1889 give a period of 62·68 years, and T = 1840·22, a close agreement.

The following is a comparison between the measures and the positions computed from the above elements:—

Epoch.	Observer.	θ_o	θ_c	$\theta_o - \theta_c$	ρ_o	ρ_c	$\rho_o - \rho_c$
		°	°		″	″	″
1835·32	Sir J. Herschel	351·6	355·4	−3·4	...	0·98	...
1835·89	,,	354·3	354·3	0·0	0·75	0·87	−0·1
1836·38	,,	357·3	353·5	+3·8	...	0·78	...
1856·20	Jacob	20·6	22·3	−1·7	0·7 est.	0·48	+0·22
1857·973	,,	13·71	16·37	−2·66	1·11	0·65	+0·46
1860·684	Powell	12·8	11·5	+1·3	...	0·89	...
1870·233	,,	6·9	4·8	+2·1	1·5 est.	1·59	−0·09

Epoch.	Observer.	θ_o	θ_c	$\theta_o-\theta_c$	ρ_o	ρ_c	$\rho_c-\rho_c$
1871·386	Russell	3°·8	4°·3	−0°·5	1″·18	1″·66	−0″·48
1873·364	„	4·2	3·6	+0·6	2·29	1·76	+0·53
1874·260	„	1·6	3·3	−1·7	1·61	1·80	−0·19
1876·63	Ellery	8·5	2·6	(+5·9)	1·3	1·88	−0·58
1880·44	Russell	1·3	1·6	−0·3	1·39	1·97	−0·58
1882·22	Tebbutt	2·1	1·1	+1·0	...	...	...
1887·526	Pollock	358·5	359 6	−1·1	1·75	1·89	−0·14
1887·583	Tebbutt	359·1	359·6	−0·5	1·76	1·89	−0·13
1888·22	„	360·4	359·44	+0·96	1·56	1·86	−0·30
1888·325	„	...	359·41	...	1·70	1·86	−0·16
1888·335	„	358·9	359·41	−0·51	1·83	1·86	−0·03
1888·605	„	...	359·3	...	2·73	1·85	+0·88
1888·61	„	359·7	359·3	+0·4	...	1·85	...
1889·323	Pollock	359·1	359·1	0·0	1·87	1·81	+0·06
1890·361	Tebbutt	359·0	358·8	+0·2	1·84	1·76	+0·08

According to the above orbit the distance is now rapidly diminishing, and about the year 1901 will be reduced to about 0″·05, when it will probably pass beyond the reach of all existing telescopes.

Assuming the mass of the system to be equal to the mass of the Sun, the "hypothetical parallax" will be

$$\pi = aP^{-\frac{2}{3}} = 0''{\cdot}096$$

For a mass equal to twice the Sun's mass, the parallax would be 0″·076.

Note on the Orbit of α Centauri. By E. B. Powell, M.A., C.S.I.

In the *Monthly Notices*, No. 6, of April 1886, I submitted a paper on the orbit of *α Centuari*, in which the following elements were put forward :—

P = 87·438 years	$\gamma = 79^\circ\ 47'\ 8''$
T = 1875·447	$\Omega = 25\ 49\ 38$
e = ·544326	$\lambda = 48\ 59\ 17$

and at the end of the paper I pointed out that in six or eight years, provided careful observations were taken, it would probably become apparent whether the period of that binary included only some seventy-six years or extended over eighty-six years or more. I cannot help thinking that now the evidence is

pretty decisive in support of the period extending over the longer time.

Taking the epochs from 1881 onwards, the following table gives a comparison, so far as the position-angle is concerned, of the results of observation (1) with those of the Downing-Elkin orbit, and (2) with those of the elements specified above.

Table of Comparison.

Observer.	Epoch 1800+	θ_o	Downing–Elkin Orbit. θ_c	Downing–Elkin Orbit. $\theta_o - \theta_c$	My Orbit of 1886. θ_c	My Orbit of 1886. $\theta_o - \theta_c$
Tebbutt	81·655	193°·15	194°·14	− °·99	193°·55	−°·40
Gill and Elkin	83·500	198·00	198·89	− ·89	198·14	−·14
Tebbutt	84·533	199·80	200·53	− ·73	199·75	+·05
„	85·580	201·02	201·86	− ·84	201·03	−·01
Pollock	86·517	202·17	202·66	− ·49	201·97	+·20
Tebbutt	86·603	201·80	202·89	−1·09	202·05	−·25
„	87·681	202·20	203·81	−1·61	202·96	−·76
„	88·467	203·20	204·47	−1·27	203·55	−·35
„	90·519	205·00	206·01	−1·01	204·87	+·13
„	91·587	206·09	206·69	− ·60	205·46	+·63

It may be well to note that the annual angular motion between successive epochs, omitting 1886·517, is as follows, according to the two orbits:—

Downing–Elkin.	Orbit of 1886.		Downing–Elkin.	Orbit of 1886.	
2·57	2·49	Interval nearly two years.	·85	·84	
			·84	·75	
1·59	1·56		·75	·64	Interval slightly more than two years.
1·27	1·22				
1·01	1·00				
			·64	·55	

It will be seen that the Downing-Elkin orbit of 76·222 years now puts the comes a degree or so in advance of the observed position, while the orbit of 87·438 years generally agrees with the measured angles within what may perhaps be termed tolerably fair limits, having regard to the errors incidental to taking measures, the latest angle observed being in all probability somewhat too large. In making this remark I by no means imply that the elements given at the commencement of this note are absolutely correct; I believe they will all be found to need modification; but I consider the period is within (say) a year of the truth, and that the changes required in the others will be only small.

The semi-axis major, 18″·89, arrived at by me in 1886, is

undoubtedly too great. It is to be recollected that till lately, omitting from notice Sir John Herschel's observations, the distance measures, from which the value of the semi-axis has to be drawn, were generally much less than the quantity to be derived from them; consequently, a small error in a measure entailed a comparatively large one on the semi-axis. Now, however, for a good many years, the semi-axis will be less than the distance measures; therefore the former will no doubt be obtained with very considerable accuracy. So far as I can judge at present, the semi-axis major will not differ much from 18″·4.

It is to be hoped that observers occupying favourable localities will spare some portion of their time for the observation of *α Centauri*. Of late years, so far as I am aware, Mr. Tebbutt has been left almost alone to occupy the field; and all who are interested in the orbit of that binary must feel that they are much indebted to that astronomer for his assiduous attention to the star.

Streatham Hill:
1892 *April.*

Estimations of the magnitude of Nova Aurigæ.

By J. Gerh. Lohse.

1892 February 1, $6^h\ 25^m$ G.M.T., 26 Aurigæ = Nova, 26 Aurigæ 1 Nova, Nova 3 *b*. The star *b* is south preceding of Nova Aurigæ.

February 3, $11^h\ 10^m$ G.M.T., Nova 2 χ Aurigæ.
February 4, $6^h\ 40^m$ G.M.T., Nova = χ Aurigæ.
February 5, $7^h\ 20^m$ G.M.T., Nova 3, perhaps 5, χ Aurigæ.
February 6, $7^h\ 10^m$ G.M.T., Nova 7 χ Aurigæ.
February 8, $8^h\ 0^m$ G.M.T., Nova Aurigæ not certainly identified owing to the close neighbourhood of the Moon. If the identification is right Nova is 8 χ Aurigæ.
February 9, $10^h\ 25^m$ G.M.T., Nova 3 χ Aurigæ, $10^h\ 40^m$ G.M.T., Nova 2 χ Aurigæ.
February 10, $7^h\ 40^m$ G.M.T., Nova = χ Aurigæ.
February 22, $10^h\ 48^m$ G.M.T., 26 Aurigæ 3 Nova, Nova = *b*, Nova is a little red.
March 23, $11^h\ 0^m$ G.M.T., Nova has become invisible.
March 24, $10^h\ 30^m$ G.M.T., Nova is invisible.

The observations were made with an opera-glass by Schröder.

The magnitudes of the comparison stars are according to the Bonn Durch-Musterung: χ Aurigæ = 4·8 magnitude, 26 Aurigæ =6·0 magnitude, *b* = 6·2 magnitude.

The observations make *b* ·3 of a magnitude fainter than 26 Aurigæ, 6·3 has therefore been adopted for the magnitude of

b, while the values of the Durch-Musterung were taken for the two other stars.

The estimated magnitudes of Nova Aurigæ therefore are :—

Date. 1892.	Greenwich Mean Time. h m	Magnitude of Nova Aurigæ.
Feb. 1	6 25	6·0
3	11 10	4·6
4	6 40	4·8
5	7 20	4·4
6	7 10	4·1
8	8 0	4·0 (?)
9	10 32	4·55
10	7 40	4·8
22	10 48	6·3
Mar. 23	11 0	Invisible with the Opera-Glass.
24	10 30	„ „ „

Comparison of Magnitudes of Nova Aurigæ and neighbouring stars, made with the Newall Telescope, Observatory, Cambridge. By H. F. Newall, M.A.

Observations on the brightness of the Nova have been made on many occasions since the discovery of the star was announced. Those of more recent date may be of interest, since all the comparison stars are mapped by Burnham (*Monthly Notices*, April, p. 433).

1892.	Nova.	Burnham's Comparison Stars.
Mar. 24	Fainter than	F 10·4
29	Brighter than	G 11·5
31	Equal to	G 11·5
	Brighter than	H 11·8
	Fainter than	E 11·7
Apr. 1	Fainter than	E 11·7
6	Fainter than	I 11·8
8	Fainter than	J 12·7
11	N. glimpsed whilst B 14·8 was not seen.	
13	N. suspected once in many attempts to see it.	
19	N. not seen or glimpsed, though B 14·8 and M were seen.	
27	N. not seen; ground dark and comparison stars well seen.	

The companion to E was well seen, but C and D have not been seen. K I cannot speak of. All the other stars were

included in comparisons, but the companion to L was not even suspected.

I should have estimated magnitudes in all cases higher than Burnham's numbers, but my experience is not yet sufficient to warrant my committing myself to numerical estimates, and unfortunately our wedge photometer has only just been received, so that no measures have been made, though observations of faint stars chosen by the American Committee for stellar magnitude standards lead me to the view I have expressed about estimating magnitudes.

Observatory, Cambridge:
1892 *May* 13.

On a Diagram useful as a Guide in adjusting a Diffraction-Grating Spectroscope. By H. F. Newall, M.A.

The diagram which this note describes is intended to give at a glance the interpretation of the well-known relation

$$m\lambda = d(\sin\phi + \sin i)$$

which connects the angles of incidence i and of emergence ϕ of a beam of light of wavelength λ in a spectrum of order m produced by a plane diffraction grating, on which lines are ruled with an interval d between them.

The diagram has been constructed for a grating ruled with 14438 lines to the inch, which gives $d = 17592 \times 10^{-7}$ mm.

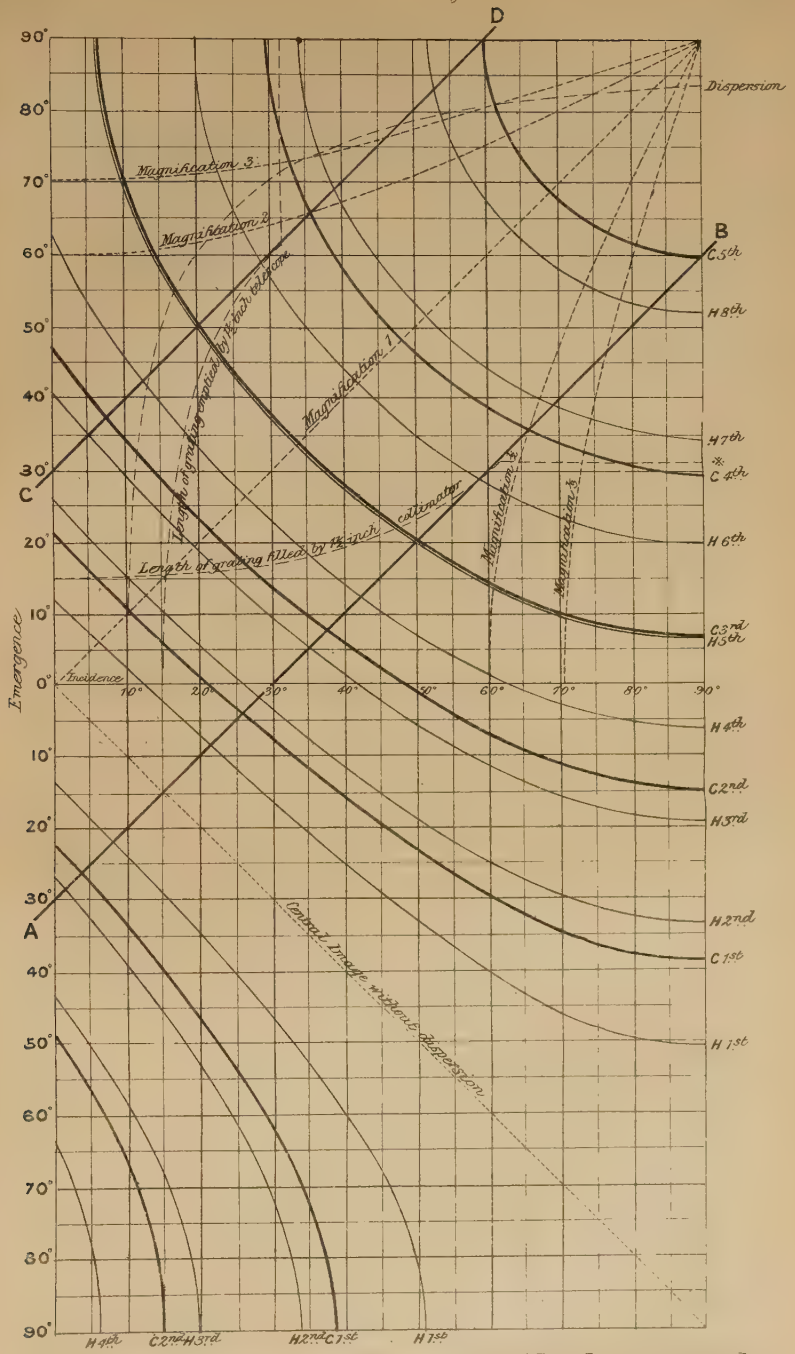
Two rectangular axes are taken; the length of incidence is represented by the length of a line measured off along the horizontal axis, which shall be called the axis of incidence; the angle of emergence of any diffracted beam is represented by a line measured off along the vertical axis, or axis of diffraction.

To explain the construction of the diagram, I describe the plotting of one curve. The following table shows the angle of emergence for the C line in the spectrum of the third order for varying angles of incidence. In above equation, $m=3$, $\lambda = 656{\cdot}18 \times 10^{-6}$ mm.

Incidence.	Emergence.	Incidence.	Emergence.
°	° ′	°	° ′
0	—	50	20 39
10	70 55	60	14 38
20	50 57	70	10 19
30	38 13	80	7 42
40	28 25	90	6 49

These values are plotted on the diagram, and the points so obtained are joined by a continuous curve.

Proceeding similarly for other orders of spectra, we cover



* If incidence is greater than 61°, some of incident beam is wasted.

To accompany Note by H. F. Newall on a diagram useful as a guide in adjusting a diffraction grating spectroscope.

the diagram with curves for the C line. Again *mutatis mutandis* for the H line.

For application to the case of any particular spectroscope, we must consider what may be called the constraints of the spectroscope.

I. If the telescope and collimator are relatively fixed at an angle θ, whilst the grating is free to turn so as to make any incidence possible, then the emergence must satisfy the constraining condition $i \pm \phi = \theta$, and the sequence of phenomena in the telescope, as the grating is turned from a position in which incidence is perpendicular to a position in which incidence is grazing, is represented by the sequence of curves cut by a straight line $i \pm \phi = \theta$ (const.).

For instance, if telescope and collimator are inclined at an angle of 30°, we get the sequences along the lines AB and CD, which cut the axes at points corresponding to 30°, and are inclined at 45° to the axes.

II. If the grating and collimator be relatively fixed, so that the incidence is constant whilst the telescope is free to turn so as to catch a beam issuing with any angle of emergence, the sequence of phenomena in the telescope as it turns is shown by the sequence of curves cut by the straight line $i = \text{const.}$, which is a line parallel to the axis of diffraction.

III. If the grating and telescope are relatively fixed, so that the angle of emergence is constant, whilst the angle of incidence may be varied by turning the telescope and grating with respect to the collimated beam, then the sequence of phenomena in the telescope is shown on the line $\phi = \text{const.}$, a straight line parallel to the axis of incidences.

When the angles of incidence and emergence are such that the width of the beam is diminished by the action of the grating, then the action of the grating is magnifying, quite apart from the magnifications produced by the use of the telescope. I have plotted on the diagram lines of equal magnification for the arbitrary values 3, 2, 1, $\frac{1}{2}$, $\frac{1}{3}$ of the magnification.

The dispersion may be shown by another curve. I have plotted a curve on the diagram to show the relative dispersion in any spectrum, taking as unity the dispersion in that spectrum when it is observed when the telescope is perpendicular to the grating. In passing from a given order of spectrum to another, account must be taken of the change of order in considering the dispersion.

In much astronomical work the needless loss of light is to be avoided. It is of assistance, therefore, to have a curve showing what length of the grating is filled by a collimator of given aperture at varying incidences. I have plotted such a curve for a collimator of aperture 1·5 inches, and for a grating whose ruled

surface is $3\frac{1}{8}$ inches long. A second curve shows what length of grating will fill the telescope of aperture 1·5 inches at varying angles of emergence of the diffracted beam.

Consider a case in which it is desired to observe the C line in the spectrum of third order with a spectroscope in which the telescope and collimator are fixed at an angle of 30°. On the diagram it is seen that two positions of the grating are possible —one in which the action of the grating is magnifying, the other where it is the reverse. Which of these positions is best will depend on the object of the observation.

In this connection it may be remarked that the actual brightness of the spectra produced by a given grating probably depends on conditions which cannot be completely controlled, in the shape of the groove cut by the ruling diamond. The brightness of a given spectrum for given values of incidence and emergence is in general different according to which end of the ruled lines is uppermost (the lines being considered vertical). Hence, if particular values of incidence and emergence are desirable, the brightness may be in general increased or diminished by turning the grating "head for tail."

I am induced to publish the diagram, because I have found it of very great assistance in designing a spectroscope, and also in actual use of a grating spectroscope. So far as I am aware, no such diagram is accessible, though the simplicity of its construction would lead one to expect it has been long in use in laboratories.

Comet Swift, March 1892. By H. C. Russell, B.A., F.R.S.

We received the cablegram of the discovery of this comet on March 9, but owing to clouds could not see it until the morning of the 11th, when some micrometer measures were obtained, also a photograph, showing five equidistant rays, the outside ones enclosing an angle of 25°. There was not much difference in their length, the longest one measuring 35 minutes of arc. The exposure given was 1 hour 50 minutes, but owing to the frequent passage of thin cloud and the bright moonlight the picture of the rays is very faint. Cloudy weather again intervened, and we did not see the comet until the morning of the 22nd, when the air was much clearer, but there was a good deal of passing cloud; during an exposure of 2 hours 23 minutes clouds covered the comet for 28 minutes; the $11\frac{1}{2}$-inch equatoreal showed no tail except a slight hazy extension, and not a sign of any ray. The photograph shows no less than eight rays, two of which extend to the edge of the photograph and may have been even longer; the recorded length is, however, 1° 10′. On the side of these two long rays three new rays appear, and one of

these, shown in the photograph of March 11 as springing from the head, is now found at some distance from the head, and not visibly joined to it. The longest rays, as well as the three new ones, are on the south side of the tail, and these seem to have a definite connection with a jet from the nucleus, which extends forwards and then bends round to these rays.

On the morning of March 25 a break in the clouds occurred just before daybreak, and a photograph was taken with 15 minutes' exposure. This shows some of the rays close to the head, and the coma two-thirds of the diameter of it is shown on March 22. This affords a measure of the brightness of these parts, for with a similar sensitive plate, and 6 minutes' exposure, a star of the 11th magnitude would be photographed.

The rays in all the photographs are very faint, and their full extent only seen by looking through the negatives at a suitable light or at a cloudy sky. I send the negative of March 22, which shows the rays best. It will be observed that the plate has a *réseau* on it, and is, in fact, a star plate; and this afforded the opportunity of making an enlarged drawing of it, the details being very carefully drawn in each square by Mr. Sellors, so that the length, breadth, and positions of the rays are shown to scale. Their relative brilliance has been slightly increased in the drawing, so that they can be more easily seen in the photographic copies sent herewith than in the original. The weather and the moonlight have been against the photographs and the observations, and perhaps may to some extent account for the fact that these rays could not be seen with the 11½-inch. However, from their relative strength in the photograph, I am disposed to think that their actinic light is stronger than that of other parts—in fact, that we have here a picture of selected parts, selected by their actinic brightness, just as the sensitive plate brings to view in the brighter parts of some nebulæ details of structure which are invisible, under circumstances which seem to leave no doubt that the sensitive plate makes a selection amongst celestial colours as it does amongst terrestrial ones. I send (1) original negative of Swift's Comet, March 22; (2) negative of drawing of above, and (3) paper negative of the same. We obtained on the mornings of March 11, 22, 24 and 25 measures of the position of the comet with the 11½-inch equatoreal and filar micrometer. Those on the 24th were measured from a star not in the catalogues, which has not yet been observed.

Observatory, Sydney:
1892 *March* 27.

The photographs are placed in the Library.

Observations of Comet Swift, March 1892.

Filar Micrometer Observations, made with the 11½-inch refractor of the Sydney Observatory.

1892	Syd. M. T.	Δ R.A.	Δ N.P.D.	cp.	R.A. app.	log p. Δ	N.P.D. app.	log p. Δ	Red. to app. place.	✱	Observer.
	h m s	m s	′ ″		h m s		° ′ ″		s ″		
March 10	16 17 31	−0 18·97	+1 45·3	3	19 14 10·28	9·662*n*	118 43 34·2	0·359	−0·84 +5·6	1	R. P. Sellors
,, 21	16 50 20	−1 28·90	−5 24	11	20 4 33·15	9·589*n*	108 22 55·0	0·495	−0·70 +8·5	2	R. P. Sellors
,, 24	17 37 45	+2 34·42	+8 39·6	4	20 17 30·33	9·488*n*	105 16 7·0	0·503	−0·62 +9·2	3	H. C. Russell

Mean Places of Comparison Stars for 1892·0.

✱	R.A. 1892·0.	N.P.D. 1892·0.	Authority.
	h m s	° ′ ″	
1	19 14 30·09	118 41 43·3	Arg. Gen. Cat. 26481
2	20 6 2·75	108 27 48·9	Wash. Zones (1848), Zone 185, No. 77
3	20 14 56·53	105 7 18·3	β^2 *Capricorni*) Conn. des Temps, 1892

Observations of Swift's Comet (a 1892), made at the Royal Observatory, Greenwich.

(Communicated by the Astronomer Royal.)

The observations were made with the East, or Sheepshanks, equatorial, aperture 6·7 inches, by taking transits over two cross wires at right angles to each other, and each inclined 45° to the parallel of declination.

Magnifying power 55. The observations are corrected for refraction, but not for parallax.

Greenwich Mean Solar Time.	Observer.	✐−✶R.A.	Corr. for Refraction.	Log factor of Parallax.	✐−✶N.P.D.	Corr. for Refraction.	Log factor of Parallax.	No. of Comps.	Appt. R.A. of ✐	Appt N.P.D. of ✐	Comp. Star.
d h m s		s	s		′ ″	″			h m s	° ′ ″	
Apr. 22 14 7 0	A.C.	+ 30·57	+0·09	9·5786	+10 44·2	+0·1	0·8224	5	22 5 37·38	76 4 57·6	*a*
26 14 11 37	T.H.	+ 12·21	−0·03	9·5850	− 5 55·3	−0·3	0·8111	5	22 18 26·74	72 47 39 8	*b*
26 14 20 44	A.C.	+ 13·89	−0·03	9·5836	− 5 55·6	−0·1	0·8071	4	22 18 28·42	72 47 39·7	*b*
29 14 17 46	L.	+ 26·50	+0·04	9·5893	+ 9 39·9	+0·3	0·7995	4	22 27 48·29	70 29 29·3	*c*
29 14 21 57	C.D.	+ 26·65	+0·04	9·5884	+ 9 43·8	+0·2	0·7973	4	22 27 48·44	70 29 33·1	*c*
May 5 13 27 37	L.	+ 53 08	+0·10	9·6027	+16 24·0	+0·7	0·8134	3	22 45 40·06	66 14 44·6	*d*
5 13 38 7	,,	+ 9·75	−0·04	9·6040	− 6 28·1	−0·1	0·8068	2	...	...	*e*
5 13 43 42	,,	+ 18·13	+0·00	9·6044	+ 0 36·1	+0·0	0·8044	2	...	...	*f*
6 13 52 5	A.C.	+ 74·87	+0·05	9·6066	+13 32 4	+0·3	0·7953	3	22 48 38·83	65 34 17·8	*g*
6 14 1 37	,,	− 8·92	−0·03	9·6058	− 9 17 0	−0·1	0·7835	5	22 48 38·73	65 34 1·2	*h*
6 14 7 33	,,	+230·93	−0 06	9·6051	−24 22·5	−0·2	0·7836	2	22 48 37·78	65 33 57·1	*d*
7 13 58 17	B.	−393·70	−0·03	9 6080	− 8 28·3	0·0	0·7863	1	22 51 30·44	64 54 59·4	*k*
7 14 8 55	,,	+361·15	−0·03	9·6069	−11 12·2	−0·2	0·7786	1	22 51 34·31	64 55 3·3	*l*
7 14 15 26	,,	−620·00	−0·03	9·6053	−12 20·3	0·0	0·7738	2	22 51 30·45	64 54 45·2	*m*

Comparison Stars.

Star's Name.	Mean R.A., 1892·0.	Mean N.P.D., 1892·0.	Authority.
	h m s	° ′ ″	
a. W.B. (1) XXII., 51	22 5 7·27	75 54 0·1	Glasgow Observations, 1870.
b. W.B. (1) XXII., 338	22 18 15·11	72 53 22·2	Weisse's Bessel.
c. 39 Pegasi	22 27 22·29	70 19 35·8	Greenwich Observations 1887 and 1890, combined with Ten-Year Catalogue, 1880.
d. μ Pegasi	22 44 37·39	65 58 6·7	Greenwich Five-Year Catalogue of Fundamental Stars, 1890.
e. B.D. + 23° 4621	22 45 32·4	66 20·8	Bonn Observations, vol. iv.
f. Anonymous	22 45 (24)	66 14	
g. B.D. + 24° 4678	22 47 24·42	65 20 32·0	Bonn Observations, vol. vi.
h. B.D. + 24° 4681	22 48 48·19	65 43 5·4	,, ,, ,,
k. W.B. (2) XXII., 1292	22 58 4·72	65 3 15·1	Weisse's Bessel.
l. W.B. (2) XXII., 1026	22 45 33·66	65 6 2·6	,, ,,
m. 56 Pegasi	23 1 51·05	65 6 53·0	Greenwich Observations, 1887, 1889, 1890, combined with Ten-Year Catalogue, 1880.

Notes.

April 26.—The comet was very faint and difficult to observe owing to mist. April 29.—Both observers noticed a short tail.

The places of the comet agree closely with Berberich's Ephemeris.

The initials L., A.C., T.H., B , C.D , are those of Mr. Lewis, Mr. Crommelin, Mr. Hudson, Mr. Bryant, and Mr. Davidson respectively.

Partial Eclipse of the Moon, 1892 May 11.

(*Communicated by the Astronomer Royal.*)

The following occultations of small stars were observed at Greenwich during the eclipse. Mr. Criswick (C.) used the 10-inch companion telescope to the photographic equatoreal and the clock Dent 2017. Mr. Lewis (L.) used the Sheepshanks equatoreal, aperture 6·7 inches, and the clock Earnshaw. Mr. Bryant (B.) used the altazimuth, aperture 4 inches, and the clock Graham I.

Star.	Observer.	Time Recorded.	Clock Fast.	Sidereal Time.	Mean Solar Time.
		h m s	s	h m s	h m s
B.D. −19° 4091 Dis.	L.	13 37 13·2	5·03	13 37 8·0	10 16 31·1
„ „ „	B.	13 37 40	31·29	13 37 8·7	10 16 31·8
„ −19 4093 „	L.	13 40 45 (*a*)	5·03	13 40 40	10 20 2·5
„ „ „	C.	13 41 42·5	38·90	13 41 3·6	10 20 26·1
„ −18 4047 Re.	L.	13 52 30 (*b*)	5·06	13 52 25	10 31 46
„ −19 4095 Dis.	„	13 55 42·5	5·06	13 55 37·4	10 34 56·5
„ „ „	C.	13 56 15·0 (*c*)	38·91	13 55 36·1	10 34 55·2
„ „ „	B.	13 56 15 (*d*)	31·21	13 55 44	10 35 3
„ −19 4096 „	C.	14 3 54 (*e*)	38·92	14 3 15·1	10 42 33·9
„ −19 4087 Re.	„	14 19 0·0 (*f*)	38·92	14 18 21·1	10 57 37·5
„ −19 4097 Dis.	„	14 31 2·0	38·93	14 30 23·1	11 9 37·5
„ „ „	L.	14 29 50 (*g*)	5·13	14 29 44·9	11 8 59·4
„ −19 4099 „	„	14 32 56·5 (*h*)	5·13	14 32 51·4	11 12 5·4
„ „ „	„	14 33 4·3	5·13	14 32 59·2	11 12 13·2
„ „ „	C.	14 33 38·0	38·93	14 32 59·1	11 12 13·1
„ „ „	B.	14 33 25	31·08	14 32 53·9	11 12 7·9
„ −19 4091 Re.	L.	14 55 1·2	5·17	14 54 56·0	11 34 6·4

Notes.

(*a*) The time was noted as uncertain to the extent of 2ˢ. It does not appear to have been a true occultation.
(*b*) The time was noted as very rough.
(*c*) Considered a good observation.
(*d*) The time was noted as rough.
(*e*) Very faint; noted as doubtful.
(*f*) Time doubtful; a little way from limb when first seen.
(*g*) Glided along limb for some seconds.
(*h*) This is a double star; the times of disappearance are for the two components.

The following observations of the progress of the shadow were made by Mr. Lewis and Mr. Crommelin (A. C.) with the Sheepshanks and Mr. Bryant with the altazimuth :—

First Contact.

Phenomenon.		Observer.	Sidereal Time. h m s
Limb very smoky		A.C.	12 28 55
Contact of true shadow		,,	12 31 55

Immersions of Craters.

Grimaldi	I.L.	A.C.	12 37 47
,,	,,	B.	12 36 44
,,	II.L.	A.C.	12 40 52
Aristarchus	I.L.	,,	12 38 45
,,	II.L.	,,	12 39 37
Copernicus	I.L.	,,	12 53 15
,,	II.L.	,,	12 55 50
Plato	centre	,,	12 54 40
,,	II.L.	,,	12 55 35
Tycho	I.L.	L.	13 29 22
,,	,,	B.	13 28 29
,,	centre	L.	13 31 4
,,	,,	B.	13 32 4
,,	II.L.	L.	13 32 50

Emersions of Craters.

Tycho	centre	A.C.	14 43 16
,,	II.L.	,,	14 45 4
Grimaldi	I.L.	,,	14 48 15
Aristarchus	centre	,,	15 10 15
,,	II.L.	,,	15 10 53
Copernicus	I.L.	,,	15 13 38
,,	centre	,,	15 14 55
,,	II.L.	,,	15 16 14

Observations of Occultations of Stars by the Eclipsed Moon on 1892 May 11, at the Radcliffe Observatory, Oxford.

Communicated by E. J. Stone, Esq., F.R.S., Radcliffe Observer.

The following Disappearances were observed by Mr. Wickham, using the Barclay Equatoreal with power 90 and Solar Chronometer Dent 44675.

Name.	Mag.	Time by Chronometer.	Observed G.M.T.	Remarks.
		h m s	h m s	
B.D. −18° 4047	9·0	9 48 13·2	9 47 56·6	Good; instantaneous.
−19 4091	8·3	10 15 24·2	10 15 7·5	Very good.
−19 4093	9·2	10 19 4·3	10 18 47·6	Rather slow.
−19 4095	8·9	10 33 22·2	10 33 5·4	Good.

The disappearance of B.D. −19° 4087 was not seen, being too near the illuminated limb.

The reappearance of B.D. −18° 4047, mag. 9·0, was looked for, both before predicted time and for quite five minutes after. The observer then suspecting some error, turned rapidly to the chronometer to check his count; looking back immediately into the telescope he saw the star had just reappeared and was still in contact with the limb. The G.M.T. of reappearance $10^h\ 30^m\ 47^s$ is, therefore, approximate only.

At $10^h\ 43^m$ the sky became overcast, and continued so during the remaining time of the eclipse.

Radcliffe Observatory, Oxford:
1892 May 13.

Ephemeris of the Satellites of Mars, 1892. By A. Marth.

		Phobos.			*Deimos.*				
Greenwich Noon.	P	a_1	b_1	u_1-U	a_2	b_2	u_2-U	U	B
1892.	°	″	″	°	″	″	°	°	°
June 10	1·46	22·43	−6·13	255·92	56·12	−15·34	244·54	267·67	−15·86
12	1·10	22·91	6·28	353·12	57·33	15·71	94·31	268·24	15·90
14	0·77	23·40	6·42	90·36	58·57	16·07	304·12	268·77	15·93
16	0·46	23·91	6·56	187·63	59·83	16·43	153·97	269·26	15·94
18	0·18	24·42	6·70	284·93	61·11	16·77	3·86	269·72	15·93
20	359·92	24·94	−6·84	22·28	62·41	−17·11	213·79	270·14	−15·91
22	359·68	25·47	6·97	119·67	63·73	17·43	63·76	270·51	15·87
24	359·48	26·00	7·09	217·10	65·06	17·74	273·77	270·83	15·82
26	359·30	26·53	7·20	314·57	66·40	18·03	123·83	271·11	15·75
28	359·16	27·07	7·31	52·09	67·75	18·30	333·94	271·34	15·67
30	359·04	27·61	−7·41	149·66	69·10	−18·55	184·10	271·53	−15·57
July 2	358·96	28·15	7·50	247·27	70·45	18·78	34·30	271·66	15·46
4	358·90	28·69	7·59	344·93	71·79	18·98	244·55	271·75	15·33
6	358·88	29·22	7·66	82·64	73·12	19·16	94·86	271·78	15·19
8	358·89	29·74	7·72	180·39	74·42	19·31	305·21	271·77	15·04
10	358·93	30·25	−7·77	278·19	75·69	−19·43	155·61	271·70	−14·88
12	359·00	30·74	7·80	16·04	76·93	19·52	6·06	271·58	14·70
14	359·10	31·22	7·82	113·94	78·13	19·58	216·56	271·42	14·52
16	399·24	31·67	7·83	211·88	79·27	19·61	67·11	271·21	14·32
18	359·40	32·10	7·83	309·86	80·35	19·60	277·70	270·95	14·12
20	359·59	32·51	−7·81	47·89	81·35	−19·56	128·34	270·64	−13·91
22	359·81	32·88	7·78	145·96	82·27	19·48	339·02	270·29	13·70
24	0·06	33·21	7·74	244·06	83·10	19·37	189·73	269·91	13·48
26	0·33	33·50	7·68	342·19	83·83	19·23	40·48	269·49	13·26
28	0·61	33·75	7·62	80·34	84·45	19·06	251·26	269·05	13·04
30	0·91	33·95	−7·54	178·51	84·95	−18·87	102·06	268·58	−12·83
Aug. 1	1·22	34·10	7·45	276·90	85·33	18·65	312·87	268·09	12·62
3	1·54	34·20	7·36	14·89	85·59	18·41	163·70	267·59	12·42
5	1·87	34·26	7·26	113·09	85·72	18·16	14·53	267·09	12·23
7	2·20	34·26	7·16	211·29	85·73	17·90	225·36	266·58	12·05
9	2·52	34·21	−7·05	309·48	85·61	−17·63	76·18	266·08	−11·89
11	2·84	34·11	6·94	47·65	85·37	17·36	287·00	265·59	11·74
13	3·15	33·97	6·83	145·81	85·00	17·10	137·80	265·11	11·61
15	3·45	33·78	6·73	243·94	84·52	16·84	348·58	264·65	11·49

Greenwich Noon.		*Phobos.*			*Deimos.*				
1892.	P	a_1	b_1	u_1-U	a_2	b_2	u_2-U	U	B
	°	″	″	°	″	″	°	°	°
Aug. 17	3·73	33·54	6·63	342·04	83·93	16·58	199·33	264·22	11·40
19	3·99	33·26	−6·53	80·11	83·23	−16·34	50·05	263·81	−11·32
21	4·23	32·94	6·44	178·15	82·44	16·11	260·74	263·44	11·27
23	4·44	32·59	6·36	276·14	81·56	15·90	111·39	263·11	11·24
25	4·63	32·20	6·28	14·09	80·59	15·71	321·99	262·82	11·24
27	4·79	31·79	6·21	111·99	79·56	15·54	172·55	262·58	11·26
29	4·91	31·36	−6·15	209·84	78·47	−15·38	23·07	262·38	−11·30
31	5·00	30·90	6·10	307·64	77·33	15·24	233·53	262·23	11·37
Sept. 2	5·06	30·43	6·05	45·38	76·15	15·13	83·94	262·13	11·46
4	5·09	29·94	6·01	143·08	74·93	15·04	294·31	262·08	11·58
6	5·08	29·45	5·98	240·72	73·69	14·96	144·62	262·08	11·71
8	5·04	28·94	−5·96	338·31	72·43	−14·90	354·88	262·14	−11·87
10	4·97	28·43	5·94	75·84	71·16	14·85	205·09	262·24	12·05
12	4·87	27·92	5·92	173·33	69·88	14·82	55·25	262·39	12·25
14	4·74	27·41	5·91	270·76	68·59	14·80	265·36	262·58	12·46
16	4·58	26·90	5·91	8·15	67·31	14·79	115·42	262·83	12·69
18	4·38	26·39	−5·91	105·48	66·03	−14·79	325·44	263·13	−12·94
20	4·15	25·88	5·91	202·76	64·76	14·80	175·41	263·47	13·21
22	3·90	25·38	5·92	300·00	63·50	14·81	25·33	263·86	13·49
24	3·62	24·88	5·93	37·19	62·26	14·83	235·20	264·29	13·78
26	3·31	24·39	5·94	134·34	61·04	14·86	85·03	264·77	14·09
28	2·98	23·91	−5·95	231·44	59·83	−14·89	294·82	265·29	−14·41
30	2·62	23·44	5·96	328·49	58·65	14·92	144·56	265·85	14·73
Oct. 2	2·24	22·97	5·97	65·51	57·49	14·95	354·27	266·45	15·07
4	1·83	22·52	5·98	162·48	56·35	14·98	203·94	267·09	15·41
6	1·40	22·07	6·00	259·42	55·24	15·01	53·57	267·76	15·76
8	0·96	21·64	−6·01	356·32	54·15	−15·04	263·16	268·47	−16·12

The differences between successive values of u_1-U range between 2256°·90 and 2258°·20, and of u_2-U between 569°·59 and 570°·83.

The values of P, a, b, $u-U$ are to be interpolated directly for the times for which the positions of the satellites are required, and the position-angles p and distances s are then found by means of the formulæ:—

$$s \sin (p-P) = a \sin (u-U)$$
$$s \cos (p-P) = b \cos (u-U).$$

Approximate Greenwich times, at which the satellites will be at their greatest elongations (*e* in position P+90° and *w* in position P−90°), the designation, in the case of Phobos, belonging to both given times, so that an elongation on the opposite side occurs at mid-time between them :—

	Phobos.		*Deimos.*			*Phobos.*		*Deimos.*
1892.	h		h		1892.	h		h
June 10	15·6	*w*	23·3	17·3 *e*	July 12	13·1	*w*	20·7	22·2 *w*
11	14·6	*w*	22·2	23·6 *e*	13	15·8	*e*	23·5	13·3 *e*
12	13·5	*w*	21·2	14·8 *w*	14	14·8	*e*	22·4	19·6 *e*
13	12·5	*w*	20·2	21·1 *w*	15	13·8	*e*	21·4	10·8 *w*
14	15·3	*e*	23·0	12·3 *e*	16	12·7	*e*	20·4	17·1 *w*
15	14·3	*e*	21·9	18·6 *e*	17	15·5	*w*	23·2	23·3 *w*
16	13·2	*e*	20·9	24·9 *e*	18	14·5	*w*	22·1	14·5 *e*
17	16·0	*w*	23·7	16·1 *w*	19	13·4	*w*	21·1	20·8 *e*
18	15·0	*w*	22·6	22·4 *w*	20	16·2	*e*	23·9	11·9 *w*
19	14·0	*w*	21·6	13·6 *e*	21	15·2	*e*	22·8	18·2 *w*
20	12·9	*w*	20·6	19·9 *e*	22	14·1	*e*	21·8	24·5 *w*
21	15·7	*e*	23·4	11·0 *w*	23	13·1	*e*	20·7	15·6 *e*
22	14·7	*e*	22·3	17·4 *w*	24	12·0	*e*	19·7	21·9 *e*
23	13·6	*e*	21·3	23·7 *w*	25	14·8	*w*	22·5	13·0 *w*
24	16·4	*w*	24·1	14·8 *e*	26	13·8	*w*	21·4	19·3 *w*
25	15·4	*w*	23·0	21·1 *w*	27	12·7	*w*	20·4	10·4 *e*
26	14·4	*w*	22·0	12·3 *w*	28	15·5	*e*	23·2	16·7 *e*
27	13·3	*w*	21·0	18·6 *w*	29	14·5	*e*	22·1	23·0 *e*
28	16·1	*e*	23·8	24·9 *w*	30	13·4	*e*	21·1	14·1 *w*
29	15·1	*e*	22·7	16·1 *e*	31	12·4	*e*	20·0	20·4 *w*
30	14·0	*e*	21·7	22·4 *e*	Aug. 1	15·2	*w*	22·8	11·5 *e*
July 1	13·0	*e*	20·7	13·5 *w*	2	14·1	*w*	21·8	17·8 *e*
2	15·8	*w*	23·4	19·8 *w*	3	13·1	*w*	20·7	24·1 *e*
3	14·7	*w*	22·4	11·0 *e*	4	12·0	*w*	19·7	15·2 *w*
4	13·7	*w*	21·4	17·3 *e*	5	11·0	*w*	18·6	21·5 *w*
5	12·7	*w*	20·3	23·6 *e*	6	13·8	*e*	21·4	12·6 *e*
6	15·5	*e*	23·1	14·7 *w*	7	12·7	*e*	20·4	18·9 *e*
7	14·4	*e*	22·1	21·0 *w*	8	11·7	*e*	19·3	10·0 *w*
8	13·4	*e*	21·0	12·2 *e*	9	10·6	*e*	18·3	16·3 *w*
9	12·3	*e*	20·0	18·5 *e*	10	13·4	*w*	21·1	22·6 *w*
10	15·1	*w*	22·8	24·8 *e*	11	12·4	*w*	20·0	13·7 *e*
11	14·1	*w*	21·7	15·9 *w*	12	11·3	*w*	19·0	20·0 *e*

1892.	*Phobos.* h		*Deimos.* h	1892.	*Phobos.* h		*Deimos.* h
Aug. 13	10·3 *w*	17·9	11·1 *w*	Sept. 11	10·7 *w*	18·4	11·8 *w*
14	13·1 *e*	20·7	17·4 *w*	12	9·7 *w*	17·4	18·1 *w*
15	12·0 *e*	19·7	8·5 *e*	13	8·7 *w*	16·3	9·2 *e*
16	11·0 *e*	18·6	14·8 *e*	14	7·6 *w*	15·3	15·5 *e*
17	9·9 *e*	17·6	21·1 *e*	15	10·4 *e*	18·1	6·7 *w*
18	12·7 *w*	20·4	12·2 *w*	16	9·4 *e*	17·0	13·0 *w*
19	11·7 *w*	19·3	18·5 *w*	17	8·3 *e*	16·0	19·3 *w*
20	10·6 *w*	18·3	9·6 *e*	18	7·3 *e*	15·0	10·5 *e*
21	9·6 *w*	17·3	15·9 *e*	19	10·1 *w*	17·8	16·8 *e*
22	12·4 *e*	20·0	22·2 *e*	20	9·1 *w*	16·7	8·0 *w*
23	11·3 *e*	19·0	13·3 *w*	21	8·0 *w*	15·7	14·3 *w*
24	10·3 *e*	17·9	19·6 *w*	22	7·0 *w*	14·7	20·6 *w*
25	9·3 *e*	16·9	10·8 *e*	23	9·8 *e*	17·5	11·8 *e*
26	12·0 *w*	19·8	17·1 *e*	24	8·8 *e*	16·4	18·1 *e*
27	11·0 *w*	18·7	8·2 *w*	25	7·7 *e*	15·4	9·2 *w*
28	10·0 *w*	17·6	14·5 *w*	26	10·5 *w*	18·2	15·6 *w*
29	12·8 *e*	20·4	20·8 *w*	27	9·5 *w*	17·2	6·7 *e*
30	11·7 *e*	19·4	11·9 *e*	28	8·5 *w*	16·1	13·1 *e*
31	10·7 *e*	18·3	18·2 *e*	29	7·4 *w*	15·1	19·4 *e*
Sept. 1	9·6 *e*	17·3	9·4 *w*	30	6·4 *w*	14·1	10·6 *w*
2	8·6 *e*	16·2	15·6 *w*	Oct. 1	9·2 *e*	16·9	16·9 *w*
3	11·4 *w*	19·0	21·9 *w*	2	8·2 *e*	15·8	8·1 *e*
4	10·3 *w*	18·0	13·1 *e*	3	7·1 *e*	14·8	14·4 *e*
5	9·3 *w*	17·0	19·4 *e*	4	6·1 *e*	13·8	5·6 *w*
6	8·3 *w*	15·9	10·5 *w*	5	8·9 *w*	16·6	11·9 *w*
7	11·1 *e*	18·7	16·8 *w*	6	7·9 *w*	15·5	18·2 *w*
8	10·0 *e*	17·7	8·0 *e*	7	6·8 *w*	14·5	9·4 *e*
9	9·0 *e*	16·6	14·3 *e*	8	9·6 *e*	17·3	15·7 *e*
10	7·9 *e*	15·6	20·6 *e*	9	8·6 *e*	16·3	6·9 *w*

Ephemeris for Physical Observations of

Greenwich Noon.	Angle of Position of ♃'s Axis. P	L−O.	Diff.	B	Annual Parallax. A−L.	Apparent Diameter. Equat.	Phase.	Polar.
1892.	°	°		°	°	″	″	″
July 30	337·119	249·189	88	+3·006	−11·533	42·07	0·43	39·46
Aug. 1	·136	·277	75	3·017	11·437	42·44	·42	39·72
3	·150	·352	62	3·028	11·328	42·71	·42	39·97
5	·163	·414	49	3·038	11·207	42·99	·41	40·23
7	·173	·463	36	3·048	11·072	43·26	·40	40·48
9	337·180	249·499	23	+3·058	−10·925	43·53	0·39	40·74
11	·185	·522	10	3·067	10·765	43·81	·39	41·00
13	·187	·532	3	3·076	10·591	44·08	·38	41·25
15	·187	·529	17	3·085	10·404	44·36	·37	41·51
17	·185	·512	30	3·093	10·203	44·63	·35	41·76
19	337·179	249·482	43	+3·101	− 9·989	44·89	0·34	42·01
21	·171	·439	57	3·108	9·762	45·16	·33	42·26
23	·161	·382	70	3·115	9·522	45·52	·31	42·51
25	·148	·312	83	3·121	9·268	45·68	·30	42·75
27	·133	·229	96	3·127	9·001	45·94	·28	42·99
29	337·115	249·133	109	+3·132	− 8·722	46·19	0·27	43·22
31	·095	249·024	121	3·137	8·430	46·43	·25	43·45
Sept. 2	·073	248·903	134	3·141	8·125	46·67	·23	43·68
4	·049	248·769	145	3·145	7·808	46·90	·22	43·89
6	337·023	248·624	157	3·148	7·479	47·12	·20	44·10
8	336·995	248·467	168	+3·151	− 7·139	47·34	0·18	44·30
10	·964	248·299	179	3·153	6·787	47·55	·17	44·50
12	·932	248·120	190	3·154	6·424	47·75	·15	44·68
14	·898	247·930	200	3·155	6·051	47·93	·13	44·86
16	·863	247·730	209	3·155	5·668	48·11	·12	45·03
18	336·826	247·521	218	+3·154	− 5·275	48·28	0·10	45·18
20	·787	247·303	226	3·153	4·873	48·44	·09	45·33
22	·748	249·077	234	3·151	4·463	48·58	·07	45·46
24	·708	246·843	242	3·148	4·045	48·71	·06	45·58
26	·667	246·601	248	3·145	3·620	48·83	·05	45·70
28	336·625	246·353	253	+3·141	− 3·189	48·93	0·04	45·80
30	·583	246·100	258	3·137	2·752	49·02	·03	45·88
Oct. 2	·540	245·842	262	3·132	2·310	49·10	·02	45·95
4	·497	245·580	265	3·126	1·865	49·16	·01	46·01
6	·454	245·315	268	3·120	1·416	49·21	·01	46·05

Jupiter, 1892 (*continued*). By A. Marth.

Greenwich Noon.	Longitude of ☿'s Central Meridian (877°·90) I.	(870°·27) II.	Corr. for Phase.	Light-time.	A−O.	B
1892.	°	°	°	m	°	°
July 30	229·40	48·90	+0·58	38·403	237·6587	+2·5948
Aug. 1	185·26	349·50	·57	38·156	237·8423	2·6001
3	141·13	290·12	·56	37·912	238·0259	2·6053
5	97·02	230·74	·55	37·670	238·2095	2·6105
7	52·92	171·37	·53	37·431	238·3931	2·6156
9	8·82	112·02	+0·52	37·195	238·5767	+2·6207
11	324·74	52·68	·50	36·962	238·7603	2·6258
13	280·67	353·35	·49	36·732	238·9439	2·6309
15	236·61	294·03	·47	36·506	239·1275	2·6360
17	192·57	234·72	·45	36·285	239·3111	2·6410
19	148·53	175·42	+0·43	36·068	239·4948	+2·6460
21	104·50	116·13	·41	35·855	239·6784	2·6509
23	60·49	56·85	·39	35·648	239·8620	2·6559
25	16·48	357·59	·37	35·446	240·0456	2·6608
27	332·48	298·33	·35	35·249	240·2292	2·6657
29	288·49	239·08	+0·33	35·059	240·4128	+2·6705
31	244·51	179·84	·31	34·875	240·5964	2·6753
Sept. 2	200·54	120·61	·29	34·697	240·7800	2·6801
4	156·58	61·39	·27	34·526	240·9636	2·6849
6	112·63	2·17	·24	34·362	241·1472	2·6897
8	68·68	302·96	+0·22	34·205	241·3308	+2·6944
10	24·74	243·76	·20	34·056	241·5144	2·6991
12	340·81	184·56	·18	33·914	241·6980	2·7038
14	296·88	125·37	·16	33·781	241·8816	2·7084
16	252·95	66·19	·14	33·656	242·0652	2·7130
18	209·03	7·01	+0·12	33·539	242·2487	+2·7176
20	165·11	307·83	·10	33·431	242·4323	2·7211
22	121·20	248·66	·09	33·332	242·6159	2·7256
24	77·29	189·49	·07	33·243	242·7994	2·7301
26	33·38	130·32	·06	33·163	242·9830	2·7346
28	349·47	71·15	+0·04	33·092	243·1666	+2·7390
30	305·56	11·98	·03	33·031	243·3501	2·7434
Oct. 2	261·65	312·81	·02	32·980	243·5337	2·7478
4	217·74	253·63	·02	32·938	243·7172	2·7522
6	173·82	194·46	·01	32·908	243·9007	2·7565

Greenwich Noon.	Angle of Position of ♃'s Axis. P	L−O.	Diff.	B	Annual Parallax. A−L.	Apparent Diameter. Equat.	Phase.	Polar.
1892.	°	°		°	°	″	″	″
Oct. 8	336·411	245·047	270	+3·113	− 0·965	49·24	·00	46·08
10	·368	244·777	270	3·105	0·512	49·26	...	46·10
12	·326	244·507	270	3·097	− 0·058	49·26	...	46·10
14	·284	244·237	270	3·088	+ 0·396	49·24	...	46·08
16	·243	243·967	268	3·079	0·850	49·21	·00	46·06
18	336·202	243·699	266	+3·069	+ 1·301	49·17	0·01	46·02
20	·162	243·433	263	3·059	1·750	49·11	·01	45·96
22	·123	243·170	258	3·048	2·196	49·04	·02	45·89
24	·085	242·912	253	3·037	2·638	48·95	·03	45·81
26	·048	242·659	247	3·026	3·075	48·84	·04	45·71
28	336·013	242·412	241	+3·014	+ 3·506	48·73	0·05	45·60
30	335·979	242·171	234	3·002	3·930	48·59	·06	45·48
Nov. 1	·946	241·937	225	2·989	4·347	48·45	·07	45·34
3	·914	241·712	217	2·977	4·756	48·29	·08	45·19
5	·884	241·495	208	2·964	5·156	48·12	·10	45·04
7	335·856	241·287	199	+2·951	+ 5·547	47·94	0·11	44·87
9	·829	241·088	188	2·938	5·929	47·75	·13	44·69
11	·804	240·900	177	2·925	6·301	47·55	·14	44·50
13	·781	240·723	166	2·912	6·662	47·34	·16	44·30
15	·759	240·557	155	2·899	7·011	47·12	·18	44·09
17	335·739	240·402	142	+2·886	+ 7·349	46·89	0·19	43·88
19	·720	240·260	130	2·873	7·675	46·65	·21	43·66
21	·703	240·130	117	2·860	7·988	46·40	·23	43·43
23	·688	240·013	104	2·847	8·288	46·15	·24	43·19
25	·675	239·909	90	2·835	8·576	45·89	·26	42·95
27	335·663	239·819	77	+2·822	+ 8·850	45·63	0·27	42·70
29	·653	239·742	63	2·810	9·110	45·36	·29	42·45
Dec. 1	·645	239·679	50	2·798	9·356	45·09	·30	42·20
3	·639	239·629	35	2·787	9·589	44·82	·31	41·94
5	·635	239·594	22	2·776	9·808	44·54	·33	41·68
7	335·632	239·572	8	+2·765	+10·013	44·26	0·34	41·42
9	·631	239·564	6	2·754	10·204	43·97	·35	41·15
11	·631	239·570	20	2·744	10·381	43·69	·36	40·88
13	·633	239·590	34	2·734	10·544	43·40	·37	40·62
15	·636	239·624	48	2·725	10·693	43·12	·37	40·35
17	335·642	239·672	62	+2·716	+10·829	42·83	0·38	40·08
19	·649	239·734	75	2·707	10·951	42·55	·39	39·82

Greenwich Noon.	Longitude of ♃'s Central Meridian (877°·90) I.	(870°·27) II.	Corr. for Phase.	Light-time.	A−O.	B
1892.	°	°	°	m	°	°
Oct. 8	129·90	135·28	·00	32·886	244·0843	+2·7618
10	85·98	76·10	...	32·875	244·2678	2·7661
12	42·05	16·91	...	32·874	244·4513	2·7703
14	358·11	317·71	...	32·883	244·6348	2·7745
16	314·17	258·51	·00	32·902	244·8184	2·7787
18	270·22	199·30	−0·01	32·932	245·0019	+2·7829
20	226·27	140·08	·01	32·972	245·1854	2·7870
22	182·30	80·85	·02	33·022	245·3689	2·7911
24	138·32	21·61	·03	33·082	245·5524	2·7952
26	94·33	322·36	·04	33·152	245·7359	2·7992
28	50·33	263·10	−0·05	33·232	245·9193	+2·8032
30	6·32	203·83	·07	33·322	246·1028	2·8072
Nov. 1	322·29	144·54	·08	33·421	246·2863	2·8111
3	278·25	85·24	·10	33·530	246·4697	2·8150
5	234·19	25·93	·12	33·647	246·6532	2·8189
7	190·12	326·60	−0·13	33·774	246·8366	+2·8228
9	146·04	267·26	·15	33·910	247·0200	2·8266
11	101·94	207·90	·17	34·054	247·2034	2·8304
13	57·82	148·53	·19	34·206	247·3868	2·8342
15	13·69	89·14	·21	34·367	247·5702	2·8380
17	329·54	29·73	−0·24	34·535	247·7536	+2·8417
19	285·38	330·30	·26	34·711	247·9370	2·8454
21	241·20	270·86	·28	34·895	248·1204	2·8490
23	197·00	211·40	·30	35·085	248·3037	2·8526
25	152·78	151·93	·32	35·282	248·4871	2·8562
27	108·55	92·44	−0·34	35·486	248·6704	+2·8598
29	64·30	32·93	·36	35·695	248·8538	2·8633
Dec. 1	20·03	333·40	·38	35·910	249·0371	2·8668
3	335·74	273·86	·40	36·131	249·2204	2·8703
5	291·44	214·30	·42	36·357	249·4037	2·8738
7	247·12	154·72	−0·44	36·588	249·5870	+2·8772
9	202·78	95·12	·45	36·823	249·7703	2·8806
11	158·43	35·51	·47	37·063	249·9536	2·8840
13	114·06	335·88	·48	37·307	250·1369	2·8873
15	69·68	276·24	·50	37·554	250·3201	2·8906
17	25·28	216·58	−0·51	37·804	250·5033	+2·8939
19	340·86	156·91	·52	38·058	250·6865	2·8972

Greenwich Noon.	Angle of Position of ♃'s Axis. P	L−O.	Diff.	B	Annual Parallax. A−L.	Apparent Diameter. Equat.	Phase.	Polar.
1892.	°	°		°	°	″	″	″
Dec. 21	·658	239·809	89	2·699	11·059	42·27	·39	39·55
23	·669	239·898	102	2·692	11·153	41·98	·40	39·29
25	·681	240·000	115	2·685	11·234	41·70	·40	39·02
27	335·695	240·115	128	+2·678	+11·302	41·42	0·40	38·76
29	·711	240·243	141	2·671	11·357	41·14	·40	38·50
31	·729	240·384	154	2·665	11·399	40·87	·40	38·24
1893.								
Jan. 2	·748	240·538	166	2·660	11·428	40·60	·40	37·99
4	·769	240·704	178	2·655	11·445	40·33	·40	37·74
6	335·792	240·882	190	+2·650	+11·450	40·06	0·40	37·49
8	·816	241·072	201	2·646	11·443	39·80	·40	37·24
10	·843	241·273	213	2·642	11·425	39·54	·39	37·00
12	·871	241·486	225	2·639	11·395	39·29	·39	36·76
14	·901	241·711	235	2·636	11·354	39·04	·38	36·53
16	335·933	241·946	246	+2·633	+11·302	38·79	0·38	36·30
18	335·967	242·192	256	2·631	11·239	38·55	·37	36·07
20	336·003	242·448	266	2·630	11·166	38·31	·36	35·85
22	336·040	242·714	276	2·629	11·083	38·08	·36	35·63
24	336·079	242·990	286	2·628	10·990	37·85	·35	35·42
26	336·120	243·276	295	+2·628	+10·887	37·62	0·34	35·21
28	336·164	243·571	304	2·628	10·775	37·40	·33	35·00
30	336·210	243·875	313	2·628	10·654	37·19	·32	34·80
Feb. 1	336·257	244·188	321	2·629	10·524	36·98	·31	34·61
3	336·306	244·509	330	2·630	10·386	36·77	·30	34·42
5	336·357	244·839	337	+2·631	+10·239	36·57	0·29	34·23
7	336·410	245·176	345	2·633	10·084	36·38	·28	34·05
9	336·465	245·521	353	2·635	9·922	36·19	·27	33·87
11	336·522	245·874	360	2·637	9·752	36·01	·26	33·70
13	336·581	246·234	367	2·640	9·574	35·83	·25	33·53
15	336·642	246·601	374	+2·643	+ 9·390	35·65	0·24	33·36
17	336·706	246·975	381	2·646	9·199	35·48	·23	33·20
19	336·772	247·356	387	2·649	9·001	35·32	·22	33·05
21	336·839	247 743	393	2·653	8·797	35·16	·22	32·90
23	336·908	248·136	398	2·657	8·587	35·00	·20	32·76
25	336·980	248·534	404	+2·661	+ 8·371	34·85	0·19	32·62
27	337·054	248·938	410	2·665	8·150	34·71	·18	32·48
Mar. 1	337·130	249·348		2·670	7·923	34·57	·17	32·35

Greenwich Noon.	Longitude of ☿'s Central Meridian ($877^{\circ}\cdot90$) I.	($870''\cdot27$) II.	Corr. for Phase.	Light-time.	A−O.	B
1892.	°	°	°	m	°	°
Dec. 21	296·43	97·22	·53	38·314	250·8697	2·9004
23	251·99	37·51	·54	38·572	251·0529	2·9036
25	207·53	337·79	·55	38·833	251·2361	2·9067
27	163·05	278·06	·56	39 095	251·4193	+2·9098
29	118·56	218·31	·56	39·358	251·6025	2·9129
31	74·06	158·55	·57	39·623	251·7856	2·9160
1893.						
Jan. 2	29·55	98·78	·57	39·888	251·9687	2·9190
4	345·02	38·99	·57	40·154	252·1519	2·9220
6	300·48	339·19	−0·57	40·420	252·3350	+2·9250
8	255·92	279·38	·57	40·686	252·5181	2·9279
10	211·36	219·56	·57	40·952	252·7012	2·9308
12	166·79	159·73	·56	41·217	252·8843	2·9337
14	122·20	99·88	·56	41·482	253·0674	2·9366
16	77·60	40·02	−0·56	41·746	253·2504	+2·9395
18	33·00	340·16	·55	42·008	253·4334	2·9423
20	348·38	280·29	·54	42·269	253·6164	2·9451
22	303·76	220·40	·53	42·528	253·7994	2·9478
24	259·13	160·51	·53	42·785	253·9824	2·9505
26	214·49	100·61	−0·52	43·040	254·1654	+2·9531
28	169·84	40·70	·51	43·292	254·3484	2·9557
30	125·18	340·79	·49	43·541	254·5314	2·9583
Feb. 1	80·52	280·87	·48	43·788	254·7143	2·9609
3	35·85	220·94	·47	44·032	254·8972	2·9635
5	351·17	160·01	−0·46	44·272	255·0801	+2·9661
7	306·49	101·07	·44	44·509	255·2630	2·9686
9	261·80	41·12	·43	44·743	255·4459	2·9710
11	217·11	341·17	·41	44·972	255·6287	2·9734
13	172·41	281·21	·40	45·198	255·8115	2·9758
15	127·71	221·25	−0·38	45·420	255·9943	+2·9782
17	83·00	161·28	·37	45·637	256·1771	2·9805
19	38·29	101·31	·35	45·850	256·3599	2·9828
21	353·58	41·34	·34	46·058	256·5427	2·9851
23	309·86	341·37	·32	46·261	256·7255	2·9873
25	264·14	281·39	−0·31	46·460	256·9082	+2·9895
27	219·42	221·41	·29	46·653	257·0909	2·9916
Mar. 1	174·70	161·42	·27	46·841	257·2736	2·9937

The differences of successive values of the longitudes of 4's central meridian vary for I. between 1755°·28 and 1756°·09, and for II. between 1740°·01 and 1740°·83.

The following is a list of Greenwich mean times, when the zero-meridian in the assumed two systems of longitudes will pass the middle of the illuminated disc. The times between successive passages vary for I. between $9^h\ 50^m{\cdot}40$ and $50^m{\cdot}67$, and for II. between $9^h\ 55^m{\cdot}58$ and $55^m{\cdot}85$.

	I. (877°·90)	II. (870°·27)		I. (877°·90)	II. (870°·27)
1892.	h m	h m		h m	h m
July 31	9 4·7	4 25·1	Aug. 15	23 2·5	21 39·6
	18 55·2	14 20·8	16	8 53·0	7 35·3
Aug. 1	4 45·7	10 12·1		18 43·2	17 30·9
	14 36·2	20 7·7	17	4 33·9	3 26·5
2	10 17·1	6 3·4		14 24·3	13 22·2
	20 7·6	15 59·0	18	10 5·2	9 13·4
3	5 58·1	11 50·4		19 55·7	19 9·0
	15 48·5	21 46·0	19	5 46·1	5 4·7
4	11 29·5	7 41·7		15 36·6	15 0·3
	21 20·0	17 37·3	20	11 17·5	10 51·6
5	7 10·4	13 28·6		21 7·9	20 47·2
	17 0·9	23 24·3	21	6 58·4	6 42·8
6	12 41·9	9 19·9		16 48·8	16 38·4
	22 32·3	19 15·6	22	12 29·7	12 29·7
7	8 22·8	5 11·2		22 20·1	22 25·3
	18 13·3	15 6·9	23	8 10·6	8 20·9
8	4 3·7	10 58·1		18 1·0	18 16·5
	13 54·2	20 53·8	24	3 51·5	4 12·2
9	9 35·1	6 49·4		13 41·9	14 7·8
	19 25·6	16 45·1	25	9 22·8	9 59·0
10	5 16·1	12 36·3		19 13·2	19 54·6
	15 6·5	22 32·0	26	5 3·7	5 50·2
11	10 47·5	8 27·6		14 54·1	15 45·8
	20 37·9	18 23·3	27	10 35·0	11 37·1
12	6 28·4	4 18·9		20 25·4	21 32·7
	16 18·8	14 14·5	28	6 15·9	7 28·3
13	11 59·8	10 5·8		16 6·3	17 23·9
	21 50·2	20 1·5	29	11 47·2	13 15·1
14	7 40·7	5 57·1		21 37·6	23 10·7
	17 31·1	15 52·7	30	7 28·0	9 6·3
15	13 12·1	11 44·0		17 18·5	19 1·9

1892.	I. (877°·90) h m	II. (870°·27) h m		I. (877°·90) h m	II. (870°·27) h m
Aug. 31	3 8·9	4 57·5	Sept. 19	9 38·6	5 35·0
	12 59·3	14 53·2		19 29·0	15 30·6
Sept. 1	8 40·2	10 44·4	20	5 19·5	11 21·7
	18 30·6	20 40·0		15 9·9	21 17·3
2	4 21·0	6 35·6	21	10 50·7	7 12·9
	14 11·5	16 31·2		20 41·1	17 8·5
3	9 52·3	12 22·4	22	6 31·5	3 4·1
	19 42·7	22 18·0		16 21·9	12 59·7
4	5 33·2	8 13·6	23	12 2·7	8 50·8
	15 23·6	18 9·2		21 53·1	18 46·4
5	11 4·5	4 4·8	24	7 43·5	4 42·0
	20 54·9	14 0·4		17 33·9	14 37·6
6	6 45·3	9 51·6	25	3 24·4	10 28·7
	16 35·7	19 47·2		13 14·8	20 24·3
7	12 16·6	5 42·8	26	8 55·6	6 19·9
	22 7·0	15 38·4		18 46·0	16 15·5
8	7 57·4	11 29·6	27	4 36·4	12 6·6
	17 47·8	21 25·2		14 26·8	22 2·2
9	3 38·3	7 20·8	28	10 7 6	7 57·8
	13 28·7	17 16·4		19 58·0	17 53·4
10	9 9·5	3 12·0	29	5 48·4	3 49·0
	18 59·9	13 7·6		15 38·8	13 44·5
11	4 50·4	8 58·8	30	11 19·6	9 35·7
	14 40·8	18 54·4		21 10·1	19 31·3
12	10 21·6	4 49·9	Oct. 1	7 0·5	5 26·7
	20 12·0	14 45·5		16 50·9	15 22·5
13	6 2·4	10 36·7	2	2 41·3	11 13·6
	15 52·9	20 32·3		12 31·7	21 9·2
14	11 33·7	6 27·9	3	8 12·5	7 4·8
	21 24·1	16 23·5		18 2·9	17 0·4
15	7 14·5	12 14·7	4	3 53·3	2 55·9
	17 4·9	22 10·3		13 43·7	12 51·5
16	12 45·8	8 5·8	5	9 24·5	8 42·7
	22 36·2	18 1·4		19 14·9	18 38·3
17	8 26·6	3 57·0	6	5 5·2	4 33·8
	18 17·0	13 52·6		14 55·7	14 29·4
18	4 7·4	9 43·8	7	10 36·5	10 20·6
	13 57·8	19 39·4		20 26·9	20 16·2

	I. (877°·90)	II. (870°·27)		I. (877°·90)	(870°·27)
1892.	h m	h m		h m	h m
Oct. 8	6 17·3	6 11·8	Oct. 26	7 15·8	10 57·9
	16 7·8	16 7·3		17 6·2	20 53·6
9	1 58·2	2 2·9	27	2 56·7	6 49·2
	11 48·6	11 58·5		12 47·1	16 44·8
	21 39·0	21 54·1	28	8 28·0	2 40·4
10	7 29·4	7 49·7		18 18·4	12 36·0
	17 19·8	17 45·3	29	4 8·9	8 27·3
11	3 10·2	3 40·9		13 59·3	18 22·9
	13 0·6	13 36·4	30	9 40·2	4 18·5
12	8 41·4	9 27·6		19 30·6	14 13·1
	18 31·9	19 23·2	31	5 21·1	10 5·4
13	4 22·3	5 18·9		15 11·5	20 1·0
	14 12·7	15 14·5	Nov. 1	10 52·4	5 56·6
14	9 53·5	11 5·6		20 42·9	15 52·2
	19 43·9	21 1·1	2	6 33·3	1 47·9
15	5 34·3	6 56·7		16 23·8	11 43·5
	15 24·7	16 52·3	3	2 14·2	7 34·8
16	1 15·2	2 47·9		12 4·7	17 30·4
	11 5·6	12 43·5	4	7 45·6	3 26·0
	20 56·0	22 39·1		17 36·1	13 21·6
17	6 46·4	8 34·7	5	3 26·5	9 12·9
	16 36·8	18 30·3		13 17·0	19 8·6
18	2 27·2	4 25·9	6	8 57·9	5 4·2
	12 17·7	14 21·5		18 48·4	14 59·8
19	7 58·5	10 12·7	7	4 38·8	10 51·1
	17 48·9	20 8·3		14 29·3	20 46·8
20	3 39·3	6 3·9	8	10 10·2	6 42·4
	13 29·8	15 59·5		20 0·7	16 38·0
21	9 10·6	11 50·7	9	5 51·1	2 33·7
	19 1·0	21 46·3		15 41·6	12 29·3
22	4 51·5	7 41·9	10	1 32·0	8 20·6
	14 41·9	17 37·5		11 22·5	18 16·3
23	10 22·8	3 33·1	11	7 3·6	4 11·9
	20 13·2	13 28·7		16 54·0	14 7·6
24	6 3·6	9 19·9	12	2 44·5	9 58·9
	15 54·0	19 15·5		12 35·0	19 54·6
25	1 44·5	5 11·1	13	8 16·0	5 50·2
	11 34·9	15 6·7		18 6·4	15 45·9

1892.	I. (877°·90) h m	II. (870°·27) h m	1892.	I. (877°·90) h m	II. (870°·27) h m
Nov. 14	3 56·9	1 41·5	Dec. 3	0 40·4	2 23·2
	13 47·4	11 37·2		10 31·0	12 18·9
15	9 28·4	7 28·5	4	6 12·1	8 10·4
	19 18·9	17 24·2		16 2·6	18 6·1
16	5 9·4	3 19·8	5	1 53·1	4 1·8
	14 59·9	13 15·5		11 43·7	13 57·5
17	10 40·8	9 6·9	6	7 24·8	9 49·0
	20 31·3	19 2·5		17 15·3	19 44·7
18	6 21·8	4 58·2	7	3 5·9	5 40·4
	16 12·3	14 53·9		12 56·4	15 36·1
19	2 2·8	0 49·6	8	8 37·5	1 31·9
	11 53·3	10 45·2		18 28·1	11 27·6
20	7 34·3	6 36·6	9	4 18·6	7 19·1
	17 24·8	16 32·3		14 9·2	17 14·8
21	3 15·3	2 28·0	10	9 50·3	3 10·5
	13 5·8	12 23·6		19 40·9	13 6·3
22	8 46·8	8 15·0	11	5 31·4	8 57·7
	18 37·4	18 10·7		15 22·0	18 53·5
23	4 27·9	4 6·4	12	1 12·6	4 49·2
	14 18·4	14 2·1		11 3·1	14 45·0
24	9 59·4	9 53·4	13	6 44·2	0 40·7
	19 49·1	19 49·1		16 34·8	10 36·5
25	5 40·4	5 44·8	14	2 25·4	6 27·9
	15 30·9	15 40·5		12 15·9	16 23·7
26	1 21·5	1 36·2	15	7 57·1	2 19·4
	11 12·0	11 31·9		17 47·6	12 15·2
27	6 53·0	7 23·3	16	3 38·2	8 6·7
	16 43·5	17 19·0		13 28·8	18 2·4
28	2 34·1	3 14·7	17	9 9·9	3 58·2
	12 24·6	13 10·4		19 0·5	13 53·9
29	8 5·6	9 1·8	18	4 51·1	9 45·4
	17 56·2	18 57·5		14 41·7	19 41·2
30	3 46·7	4 53·2	19	0 32·2	5 36·9
	13 37·2	14 48·9		10 22·8	15 32·7
Dec. 1	9 18·3	10 40·3	20	6 4·0	1 28·5
	19 8·8	20 36·1		15 54·6	11 24·2
2	4 59·4	6 31·8	21	1 45·1	7 15·8
	14 49·9	16 27·5		11 35·7	17 11·5

	I. (877°·90)	II. (870°·27)
1892.	h m	h m
Dec. 22	7 16·9	3 7·3
	17 7·5	13 3·0
23	2 58·1	8 54·6
	12 48·7	18 50·3
24	8 29·8	4 46·1
	18 20·4	14 41·9
25	4 11·0	0 37·7
	14 1·6	10 33·4
26	9 42·8	6 25·0
	19 33·4	16 20·7
27	5 24·0	2 16·5
	15 14·6	12 12·3
28	1 5·2	8 3·9
	10 55·8	17 59·6
29	6 37·0	3 55·4
	16 27·6	13 51·2
30	2 18·2	9 42·8
	12 8·8	19 38·5
31	7 50·0	5 34·3
	17 40·6	15 30·1
1893.		
Jan. 1	3 31·3	1 25·9
	13 21·9	11 21·8
2	9 3·1	7 13·3
3	4 44·3	3 4·8
	14 34·9	13 0·6
4	10 16·1	8 52·1
5	5 57·3	4 43·8
	15 48·0	14 39·6
6	1 38·6	0 35·4
	11 29·2	10 31·2
7	7 10·4	6 22·8
	17 1·1	16 18·6
8	2 51·7	2 14·4
	12 42·3	12 10·2
9	8 23·5	8 1·8
10	4 4·8	3 53·4
	13 55·4	13 49·2

	I. (877°·90)	II. (870°·27)
	h m	h m
Jan. 11	9 36·7	9 40·8
12	5 17·9	5 32·4
	15 8·5	15 28·2
13	0 59·2	1 24·0
	10 49·8	11 19·8
14	6 31·1	7 11·4
15	2 12·3	3 3·1
	12 3·0	12 58·9
16	7 44·2	8 50·5
17	3 25·5	4 42·1
	13 16·1	14 37·9
18	8 57·4	10 29·6
19	4 38·7	6 21·2
	14 29·3	16 17·0
20	0 19·9	2 12·8
	10 10·6	12 8·6
21	5 51·9	8 0·3
22	1 33·1	3 51·9
	11 23·8	13 47·7
23	7 5·1	9 39·4
24	2 46·4	5 31·0
	12 37·0	15 26·9
25	8 18·3	11 18·5
26	3 59·6	7 10·2
27	9 31·5	12 57·6
28	5 12·8	8 49·3
29	0 54·1	4 41·0
	10 44·8	14 36·8
30	6 26·1	10 28·4
31	2 7·4	6 20·1
Feb. 1	7 39·3	12 7·6
2	3 20·6	7 59·2
3	8 52·6	3 50·9
4	4 33·9	9 38·4
5	10 5·9	5 30·1
6	5 47·2	11 17·6
7	1 28·5	7 9·3
8	7 0·5	3 1·0

	I. (877°·90)	II. (870°·27)		I. (877°·90)	II. (870°·27)
1893.	h m	h m		h m	h m
Feb. 9	2 41·8	8 48·5	Feb. 20	4 29·7	3 0·4
10	8 13·8	4 40·2	21	10 1·7	8 48·0
11	3 55·1	10 27·7	22	5 43·1	4 39·7
12	9 27·1	6 19·4	23	1 24·4	10 27·2
13	5 8·4	12 6·9	24	6 56·4	6 18·9
14	0 49·8	7 58·6	25	2 37·8	2 10·6
15	6 21·8	3 50·3		12 28·4	12 6·5
16	2 3·1	9 37·8	26	8 9·8	7 58·2
17	7 35·1	5 29·5	27	3 51·1	3 49·9
18	3 16·4	11 17·1	28	9 23·1	9 37·4
19	8 48·4	7 8·8	Mar. 1	5 4·5	5 29·1

On page 367 of vol. xli. the corrections may be found which, when applied to the longitudes of ♃'s central meridian, given in the ephemerides for the oppositions from 1875 to 1880, reduce them to the system of longitudes and the daily rate of rotation 870°·42 adopted in the ephemeris for 1881–82, and continued for the succeeding two oppositions. This rate of rotation represented the average motion of the great reddish spot during the first years of its appearance. In consequence of the reported fading away of the spot the system of longitudes referring to it was abandoned in the ephemeris for 1884–85, and another system substituted, which was better adapted for the more quickly rotating equatorial spot, but the system referring to the great spot was re-introduced as system II. in the ephemeris for 1885–86, with the altered rate 870°·31, and as the motion continued to slacken the rate was reduced to 870°·27 in the next ephemeris, and has since been employed without alteration, the zero-meridian, however, being repeatedly shifted 10°. In order to reduce the longitudes of ♃'s central meridian, deduced from the ephemerides, to the system of the present ephemeris, the following corrections must be applied :—

	Corr.	1883.	Corr.	1883.	Corr.
	°		°		°
1882. Aug. 2	+31·6	Feb. 28	+ 0·1	1883. Dec. 25	−44·9
Sept. 1	27·1	Mar. 30	− 4·4	1884. Jan. 24	−49·4
Oct. 1	22·6	Apr. 29	− 8·9	Feb. 23	−53·9
31	18·1	May 29	−13·4	Mar. 24	−58·4
Nov. 20	13·6	Sept. 26	−31·4	Apr. 23	−62·9
Dec. 30	+ 9·1	Oct. 26	−35·9	May 23	−67·4
1883. Jan. 29	+ 4·6	Nov. 25	−40·4	June 22	−71·9

For 1884–85 the longitudes of 24's central meridian, corresponding to the present ephemeris, may be deduced from the following list:—

1884.		1885.		1885.	
	°		°		°
Oct. 20	110·30	Jan. 13	284·81	Apr. 13	137·15
25	141·21	18	316·81	18	168·25
30	172·18	23	348·84	23	199·25
Nov. 4	203·21	28	20·89	28	230·16
9	234·31	Feb. 2	52·96	May 3	260·99
14	265·48	7	85·03	8	291·74
19	296·71	12	117·09	13	322·41
24	328·01	17	149·13	18	353·01
29	359·39	22	181·13	23	23·54
Dec. 4	30·83	27	213·09	28	54·01
9	62·35	Mar. 4	244·99	June 2	84·44
14	93·93	9	276·81	7	114·81
19	125·59	14	308·56	12	145·14
24	157·31	19	340·23	17	175·43
29	189·10	24	11·81	22	205·69
1885.		29	43·29	27	235·91
Jan. 3	220·95	Apr. 3	74·67	July 2	265·11
8	252·85	8	105·96	7	296·30

The differences of successive values vary between 4350°·19 and 4352°·07. The correction for phase is to be found in vol. xliv. p. 450. The longitudes of Dr. Terby's observations, made during this period, have been deduced from an ephemeris corresponding to those for 1887 and 1888, and must be increased 10°.

The corrections for the succeeding ephemerides are:—

	Corr.		Corr.
	°		
1885 Nov. 14	+10·0	1886 Dec. 9 to 1887 Sept. 5	+10°
1886 Jan. 13	+ 7·6	1887 Dec. 24 to 1888 Sept. 19	
Mar. 14	+ 5·2	1889 Feb. 26 to Oct. 24	No corr.
May 13	+ 2·8	1890 Mar. 23 to Dec. 18	
July 12	+ 0·4	1891 Apr. 17 to 1892 Feb. 11	−10°.